LENGTH OF HAUL IN RAIL FREIGHT MOVEMENTS

A Thesis Submitted
in Partial Fulfilment of the Requirements
for the Degree of
DOCTOR OF PHILOSOPHY

By

S. SRIRAMAN

to the

DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES
INDIAN INSTITUTE OF TECHNOLOGY KANPUR
MARCH, 1981

To

My Parents

and

Supervisors

CERTIFICATE

This is to certify that the thesis "Length of Haul in Rail Freight Movements" submitted by S. Sriraman in partial fulfilment of the degree of Doctor of Philosophy to the Indian Institute of Technology, Kanpur is a record of bonafide research work carried out under our supervision and guidance. The results embodied in the thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

March, 1981

TVS Ramamohan Rao
(T.V.S.Ramamohan Rao)
Professor of Economics

(S.P.Palaniswamy)
Assistant Professor
of
Transportation Engineering

CERTIFICATE

This is to certify that S.Sriraman has satisfactorily completed all the course requirements in the Ph.D.programme in Economics.

The Courses include:

H-Eco	732	Econometrics
H-Eco	735	Theory of Fiscal Policy
H-Eco	736	Industrial Organisation and Policy
H-Eco	739	Price Theory
H-Eco	741	Project Economics
H-Eco	742	Seminar on Selected Topics in Advanced Economic Analysis
CE	682	Analysis of Transportation Systems
CE	686	Rail Transportation Systems Planning and Design

S.Sriraman was admitted to the candidacy of the Ph.D. degree in March 1979 after he successfully completed the written and oral qualifying examinations.

P.N. Rastogi

(P.N.Rastogi)
Head
Department of Humanities and Social Sciences

(S.N.Mahajan)
Convenor
Departmental Post-Graduate Committee

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SYNOPSIS

There has been an acute and ever increasing shortage of wagons for freight movements on the Indian Railways for quite sometime. It has been observed, in particular, that there has been a perceptible increase in the average length of haul though the quantum shipped has been fluctuating only marginally. On the supply side, there has been a decline in the number of wagons loaded and an increase in the average turnaround time of wagons. Fundamentally, even these can be considered as consequences of the increase in the average length of haul.

Casual observation indicates that the Railway management has been favouring increases in the average length of haul with the expectation that such an option simplifies operational management as well as increases revenues. Hence, the observed length of haul is primarily determined by the decision of the shipper. The Railway management does not as yet appear to recognize the negative effects, of this increase in the average length of haul, on the supply of services as well as its revenue-earning potential.

It was therefore felt that studying the shipper's behavioural patterns with respect to the length of haul and its effects on the demand for and supply of rail freight services is of particular importance. Only such studies can provide an adequate analysis of the policy options available for reducing the persistent dynamic disequilibrium.

With these observations in perspective we made an attempt to identify a behavioural theory of shipper's decisions regarding the length of haul and quantum shipped. However, the existing literature - even that based on behavioural theories - does not deal with the choice of the length of haul. It was therefore necessary to develop an adequate theoretical framework from fundamentals. One of the important contributions of the present study is the development of the microtheoretic basis for decisions regarding the length of haul.

The framework which emerged from the exercise enabled us to disentangle the possible sources of increases in the demand for wagons and the reduction in the supply of freight services. The resulting four equation system was the theoretical basis of the empirical work that we reported in the present study.

The theoretical structure has been empirically validated for disaggregated commodity movements on the Indian Railways. The following results are particularly significant: (a) the length of haul, and not the quantum shipped, is sensitive to variations in transport rates and output prices, (b) the growth of production levels as well as the regional disparities in production and demand have been found to have a major role in determining both the length of haul and the quantum shipped. The demand factors predominate in both the decision processes, and (c) speculative movements of freight, which were expected as a result of the increase in the length of haul, are as yet of very minor consequence.

Further, to examine the efficacy of certain alternative policy measures in relation to their ability to alleviate the dynamic disequilibrium in the wagon supply, we conducted a simulation exercise on the estimated system of equations. Policies regarding the freight rate, the wagon stock, and changes in the distribution patterns have been considered as the major policy options.

One of the major findings of this exercise is that changes in the freight rates and wagon stock (within the range which appear to be sufficiently practical) can have the effect of creating a net excess supply of freight

services for most commodities. On a comparative basis, the freight rate changes are more efficacious. However, neither of these appear to be adequate in the case of fertilizers and cement. For these commodities even a combination of the two policies leaves a significant excess demand. The use of a regional warehouse concept, similar to that for foodgrains, may be highly beneficial to solving the problem of movements of fertilizers. Overall production increases may turn out to be more important in the case of cement.

The study was thus important for disentangling the factors causing dynamic disequilibrium with respect to the freight movements on the Indian Railways. However, it was felt that extensive studies regarding the supply of freight services will be necessary for developing a comprehensive and operational solution to the problem.

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CHAPTER 1

INTRODUCTION

1.1 RAIL FREIGHT MOVEMENTS

The infrastructure provided by the Indian Railway System has been one of the key factors in sustaining a growing and diversified economy. Movements of raw materials, made possible by the availability of rail freight services[1], were the prime movers of efficient utilisation of resources over both space and time. However, the initial planned efforts at economic development and the resultant investment policies themselves gave rise to further creation of demand for freight services[2].

This trend can be illustrated as follows. Table 1 exhibits a cross section view of the importance of rail freight movements for different commodity groups. Similarly, we constructed Table 2 to reflect the variations of freight movements over time for a specific commodity, viz., cement.

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1. In India the railway system was very well-developed even during British days. It proved useful for post-Independence development. The pre-Independence developments have been outlined in Khosla, G.S., Railway Management in India (Bombay: Thacker, 1972).

2. See, for example, Lefeber, L., and M. Datta Chaudhari, Transportation Policy in India, in P.N. Rosenstein- Rodan (ed.) Pricing and Fiscal Policies (Cambridge: M.I.T. Press, 1964).

TABLE 1. DEMAND FOR RAILWAY FREIGHT SERVICES[a, b]

S.No.	Commodity	Production (Million Tonnes)	Quantity Moved (Million Tonnes)	Rail Co-efficient[c] (Percent)	Average Length of Haul (Kilometres)
1.	Coal	102.70	64.30	62.6	581
2.	Iron Ore	42.20	25.59	60.7	384
3.	Iron & Steel	16.97	10.76	63.4	1005
4.	Cement	17.20	11.59	67.4	743
5.	Foodgrains	121.03	16.18	13.4	956
6.	Fertilizers[d]	3.40	7.20	211.0	859
7.	P.O.L. Products[e]	21.00	11.70	55.7	605

Note: a. The figures are for the year 1975-76.

b. The figures refer to revenue-earning tonnage.

c. Rail coefficient = $\frac{\text{Quantity Moved}}{\text{Production}} \times 100$

d. Indicates production plus imports.

e. P.O.L. products = petroleum and other liquid products

Source: (1) Ministry of Railways - Annual Statistical Statements.

(2) Central Statistical Organisation - Statistical Abstracts.

TABLE 2. TIME PROFILE OF DEMAND FOR FREIGHT MOVEMENTS[a]

Year	Production (Million Tonnes)	Quantity Moved (Million Tonnes)	Rail Co-efficient (Percent)	Average Length of Haul (Kilometres)
1960-61	8.00	6.54	81.3	372
1961-62	8.30	6.70	80.7	388
1962-63	8.90	6.85	77.5	400
1963-64	9.40	7.24	77.7	401
1964-65	9.80	7.65	78.6	431
1965-66	10.70	8.64	79.6	456
1966-67	11.10	8.89	80.2	468
1967-68	11.50	9.35	81.7	484
1968-69	12.20	9.39	77.0	527
1969-70	13.80	10.70	77.5	583
1970-71	14.40	11.02	76.4	633
1971-72	15.00	11.22	74.7	617
1972-73	15.60	10.52	67.3	641
1973-74	14.70	10.02	68.0	635
1974-75	14.70	9.18	62.6	663
1975-76	17.20	11.59	67.4	743

Note: a. These figures are for cement.

Source: (1) Ministry of Railways - Annual Statistical Statements.

(2) Central Statistical Organisation - Statistical Abstracts.

Similar patterns of freight flows have been recorded in the process of economic development for other countries as well. See, for instance, Taborga (1979)[3].

1.2 DEMAND FOR FREIGHT SERVICES

Though we have recorded the demand for rail freight services in terms of originating tonnage it does not manifest itself in that form in any practical setting. Instead, a shipper who has a demand for freight services expresses it in the form of requirements of a specific number of wagons at a predefined destination and to be made available at a well-defined point of time.

More generally, a shipper of goods and materials determines, on the basis of some economic evaluation, the quantity he wishes to move and the destination to which it will be transported[4]. In the second stage he decides the

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3. Taborga, P.N., The Economic Role of Railways - Determinants of Railway Traffic: Phase I Final Report, World Bank Mimeograph, 1979.

4. Most of the existing literature on freight movements postulates the length of haul to be exogeneous. However, the studies of Daughety, A.F., and F.S. Inaba, An Analysis of Regulatory Change in the Transportation Industry, to appear in Review of Economics and Statistics, 1981, and Rao, P.S., Forecasting the Demand for Rail Freight Services, Journal of Transport Economics and Policy, January 1978a, pp. 7-26, emphasized the need to study length of haul and its relation to the quantum shipped explicitly.

optimal mode of shipment. He will accordingly determine the demand for wagons.

The demand for freight services, especially by railways, can therefore be viewed as comprising of a vector of requirements specified by a consignee: (a) the number of wagons required, (b) the frequency with which they are needed (or, more generally, a time profile of wagon requirements), and (c) the desired delivery date at the destination to which a particular shipment is marked.

The post-Independence Indian experience indicates the following major trends. The quantum shipped has been fluctuating marginally[5]. However, there has been a significant increase in the demand for wagons. Apriori this may suggest that with the dispersal of industry, and economic activity in general, there has been a reduction in the size of shipments. But the rolling stock of the railways remained static thus causing the observed increase in the demand for wagons. However, on closer examination it has been found that the major reason for the increase in the demand for wagons is the increase in the length of haul in freight

5. In fact, in recent years, the aggregate quantum of shipments has been hovering around a constant level of 200 million tonnes.

movements. From about 650 Kms in the early seventies on an average for all commodities it has gone upto almost 750 Kms in more recent years. In the case of specific commodities the change in the length of haul has been substantial. For instance, in the case of foodgrains the average length of haul increased from 961 Kms to 1181 Kms. It may then be noted that an increase in the length of haul keeps a wagon on wheels for a longer time and thereby increases the number of wagons needed to handle a given quantum of freight shipments[6].

1.3 SUPPLY OF FREIGHT SERVICES

The railways respond to the demands on the system in several ways. We may briefly outline these as follows: (a) creation of additional track capacity and adding to wagon stock, (b) improving the scheduling and routing so as to reduce delays in transit (such as waiting time at marshalling yards, empty wagon movements, etc.), and (c) rationing out the available supply among competing users by appropriate freight rate choices and other priority specifications.

Table 3 exhibits some of the supply characteristics of the Indian Railways as they evolved over time. Though

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6. Punnose, M.G., Problems and Prospects, The Economic Times, April 27, 1980.

TABLE 3. SUPPLY OF RAILWAY FREIGHT SERVICES

Year	Wagon Stock	Wagons Loaded[a] (000's)	Turnaround Time[a] (Days)	Empty Wagon Movement[b]
1970-71	383,990	7592	13.3	30.3
1971-72	382,725	7657	13.5	29.3
1972-73	384,283	7855	13.5	28.6
1973-74	388,366	7325	15.0	29.8
1974-75	390,968	7797	14.6	29.9
1975-76	395,250	8731	13.5	31.7
1976-77	397,773	9232	13.0	33.0
1977-78	399,971	9199	13.3	32.3
1978-79	401,880	8737	14.3	31.0

Note: a. Refers to the trend on broad gauge sections. Similar trends are discernible on metre gauge sections also.

b. Percentage of empty wagon kilometrage to total wagon kilometrage.

Source : (1) Ministry of Railways - Annual Statistical Statements.

(2) Economic Times, April 27, 1980.

an overall improvement can be discerned in the wagon stock available and its actual usage, the turnaround time as well as the empty wagon movements have been on the increase.

The most disturbing feature has been the downward trend in the actual number of wagons loaded over the past few years. The commodity groups that are most affected appear to be coal, cement, and iron and steel[7]. As a result, despite the overall increase in the tonne-kilometrage and the revenue-earning freight traffic, there is a significant excess demand for freight services.[8,9]

It is generally felt that one of the major reasons for the excess demand is the shortage of wagon stock itself. The annual additions to wagon stock have been marginal. They

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7. Srichand, S., Deceleration in Wagon Loadings, The Economic Times, April 27, 1980.

8. It has been reported in the Economic Times, March 7, 1980, that the railways incurred a loss of Rs.189 crores due to their inability to lift the targeted tonnage.

9. A significant part of the excess demand gets channelled into the truck mode in the short-run even in circumstances which are visibly uneconomic. According to the Hindu, August 11, 1980, despatches of Coal India by railways decreased from 61.59 million tonnes in 1975-76 to 54.80 million tonnes in 1979-80. During the same period, despatches by road increased from 13 million tonnes to 23 million tonnes.

have been, by and large, more by way of replacements than net additions.

We therefore observe that there has been an overall shortage of freight services offered by the railways. In particular, movements of certain commodities, over specific routes and at well-defined time periods during the year, have been jeopardized.

1.4 CONSEQUENCES OF DISEQUILIBRIUM

The disequilibrium in the market for freight services may be created in the following major ways: (a) changes in the markets for raw materials and final products which are normally external to the railway system, may generate forces which create an excess demand for rail freight services. Examples of this nature will be the increases in imports (of strategic goods like foodgrains and fertilizers) and changes in the location of industry, and (b) decisions of the railway management with respect to freight services. For instance, handling delays can have a significant effect of reducing the supply. However, almost all external market forces ultimately have an effect on the demand for freight services only to the extent that they influence either the quantum shipped or the length of haul. The major source of disequilibrium has been the increase in the length

of haul. Even the railway management was directly encouraging movement over longer distances by offering freight rate concessions. To an extent this may be viewed by the railways as the easiest way of maximizing revenues. The ultimate result of all these mechanisms is the disequilibrium created by the increases in the length of haul.

There has been a tendency to augment the volume of shipments as a result of the increase in the length of haul. Firstly, any increase in the length of haul would mean that a tonne of goods travels a longer distance than it used to. This increases the inventory on wheels and consequently the volume of freight in transit. Secondly, the increase in transit time creates problems for the consignee if there is an unanticipated increase in demand. To deal with such problems the consignee maintains a safety stock. The longer and more uncertain the length of haul, the greater will be the level of the safety stock held at the destination. These precautionary increases in inventory result in corresponding shipments and an increase in the demand for rail freight services.

An increase in the length of haul has at least two deleterious effects on the services obtained from the railway system: (a) there has been an increase in the turnaround time of wagons, and (b) given the unidirectional

movement of many commodities, the haulage of empty wagons has also gone up. Both these factors have the effect of reducing the capacity of the system stated in terms of availability of wagons.

Thus, it may be noted that any initial disequilibrium in the system has a tendency to augment itself rather than generate corrective counteraction.

The management of the railways increased freight rates to discourage certain marginal users. However, there is a general feeling that the changes have been directed primarily at covering the cost increases, resulting from the price of oil, rather than creating any discernible impact on the observed disequilibrium.

Mechanisms outside the purview of railway freight services have had some equilibrating momentum. For instance, there has been a significant diversion of freight traffic to the truck mode. The second most important aspect has been the development of a regional distribution system for food-grains. This scheme of the Food Corporation of India has been in operation for a considerable period of time. It had the effect of reducing the pressure on the railway network by appropriate scheduling during slack times.

However, on the basis of available empirical evidence it appears that there has been a negligible effect of these mechanisms on the patterns of disequilibrium.

1.5 STATEMENT OF THE PROBLEM

It is evident from the foregoing analysis that a study of the excess demand situation in the market for freight services of the railway system is in order.[10]

It is also evident from the analysis of the preceding sections that the basic source of disequilibrium has been the increase in the length of haul. For all practical purposes, the choice of length of haul is determined exclusively by the shipper[11] irrespective of whether it is caused by external market conditions or the attributes of

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10. More so because even the admittedly knotty problems we have mentioned above may prove to be the tip of an iceberg. For, increases in the price of petroleum products and the reduction in the quantum available may set in motion a reversal of the trend for high-valued and short-haul freight to move by truck. If and when this occurs, the railways must be prepared to handle increases in freight movements.

11. Casual observation suggests that the railway management prefers long-haul freight movements partly to simplify their operational management and secondly to increase the revenue.

the rail freight system itself. Hence we ought to examine the decision making process of individual consignees with respect to the choice of length of haul. We primarily require a model of demand for freight services by defining it as comprising of the choices of both the quantum shipped and the length of haul.

The primary objective of the present study is to develop a behavioural theory of shipper's decisions with respect to these two aspects. The demand for wagons can then be developed on the basis of this information.

Once the analytical framework is clearly defined, we endeavour to test it empirically using the disaggregated commodity level freight movements on the Indian Railways. This serves to validate the theory as also provide credibility for its use in the context of other countries.

The increase in length of haul, apart from its effect on the demand for wagons, may also result in a reduction in wagon supply. We propose to develop a concrete assessment of this phenomenon.

The study will also be extended to shed light on the short- run possibilities which can be pursued to reduce the pressure on the available wagon stock. Such an analysis would enable us to assess the quantitative magnitude of the

residual disequilibrating forces. We will then be able to provide some guidelines regarding other possible avenues by which the market for freight services can be brought to an equilibrium configuration.

CHAPTER 2

GUIDELINES FROM THE EXISTING LITERATURE

2.1 THE PROBLEM PERSPECTIVE

In the previous chapter it has been clearly pointed out that the major aim of the present study is to examine the demand for various characteristics of freight movements. In particular, we emphasized the need to study the demand for volume of goods shipped and the length of haul in freight movements.

Since the literature on freight movements has been quite extensive we will endeavour to seek guidance from it to formalize the modelling methodology for the study. However, on quick initial perusal of the literature we found that most of the analytical developments are of recent origin and are not as yet in any steady state. Witness, for instance, the emphasis of Fresko et. al (1972)[1] that in fact serious attempts to analyze freight movements have yet to be initiated. Similarly, Smith (1974)[2] emphasized the fact that freight

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1. Fresko, D., Shunk, G., and F. Spielberg, Analysis of the Need for Goods Movement Forecasts, Journal of the Urban Planning and Development Division of the ASCE, March 1972, pp. 1-16.
2. Smith, P.L., Forecasting Freight Transport Demand- The State of the Art, The Logistics and Transportation Review, 1974, pp. 311-326.

demand forecasting is, as yet, a junior member of the forecasting models in the area of transportation.

However, and despite the relatively recent interest in studies on freight movements, we find that a very large number of practical issues have been brought to focus. Similarly, a rather rich spectrum of analytical techniques have been developed. We will review the most pertinent literature from the viewpoint of the present study. No attempt will be made to be exhaustive.

2.2 ADHOC FORECASTING MODELS

There have been a few macro-level models of freight movements. Some of them even attempted commodity level disaggregation and modal split of a given quantum of shipments.

The major postulate in the aggregate models is that the economic activity, which constitutes the basic source from which freight demand originates, can be either represented by the level of national income or population density. In the context of less developed market situations corrections have been suggested to exclude those national income transactions which are not direct market valuations. See, for instance, Lefeber and Datta Chaudhari (1964).

Some studies recognized the fact that the demand for freight services at any given location may also be influenced

by certain supply characteristics of the specific mode of transport. For instance, Loose and Roueche (1979)[3] postulated that congestion on a given mode can have a negative effect on the demand for shipments by that mode. However, there is no sustained effort at identifying the various supply characteristics that can have an important influence on freight movements.

Similarly, a study by Benheddi and Pitfield (1980)[4] indicated that certain interregional characteristics with respect to industrial activity, urbanization and so on can have differential effects on freight movements. We will actually find in the next section that the gravity models of interregional freight movements provide a much more analytically satisfactory approach to this aspect of the problem.

Studies which deal with modal split of freight movements emphasized three variables as mainly responsible for the observed outcomes. They are (a) the tariff charged

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3. Loose, V.W., and L. Roueche, Impact of Congestion on Transportation levels: Case of Ferry Transportation, Transportation Research, April 1979, pp. 79-82.

4. Benheddi, A., and D.E. Pitfield, Industrial Heterogeneity and Spatial Hierarchy in Multiregional Freight-generation Models, Environment and Planning A, July 1980, pp. 787-797.

by different modes, (b) the availability of services when needed, and (c) the nature of shipments; such as the smallness of individual shipments and the distance over which they have to be transported. In this group of analytical models, we have examples of Pathak (1976, 1980) and Rakowski (1976).[5]

A rather comprehensive statement of the various factors that require attention can be found in Taborga (1979, pp.71ff) though it does not appear to have resulted in very many empirical studies as yet. To be sure, we should be clear that these and other aspects are accounted for in models which start from a more coherent theoretical basis. We will consider them in the sequel.

To bring to focus the studies pertaining to India we recognize the following. In a rather early study, Lefeber and Datta Chaudhari (1964) reported the following results regarding the total freight traffic on railways.

$$\ln T = -3.2 + 2.37 \ln Y \,, \; R_1 = 0.94$$

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5. (i) Pathak, M.G., Roads and Road Transportation in Marathwada, Doctoral Thesis submitted to Marathwada University (unpublished),1976.

   (ii) Pathak, M.G., Economic Implications of Oil Crisis and Transport Sector in India, Energy Management, January 1980, pp. 17-23.

   (iii) Rakowski, J.R., Competition between Railroads and Trucks, Traffic Quarterly, April 1976, pp.285-301.

$$\ln T = -1.3 + 1.77 \ln X_1 \ , \ R_2 = 0.94$$

$$\ln T = -2.8 + 2.09 \ln X_2 \ , \ R_3 = 0.95$$

where Ln = natural logarithm of any given variable.

T = freight traffic on railways (billion ton-miles).

Y = net domestic product at fixed prices (Rs. billion).

X_1 = income originating in the goods producing sector, excluding non-marketed agricultural products at fixed prices (Rs. billion).

X_2 = value of gross output of the goods producing sector plus imports at fixed prices (Rs. billion).[6]

We wish to emphasize that the estimated coefficient of around 2, attached to the independent variable, is relatively uniform in all the regressions and is too high. It cannot be accepted except for a very short horizon of time. Such an approach is therefore of dubious value even as a forecasting device. We cannot place any reliance on it for long-term analysis.

The work of Palaniswamy and Gangopadhyay (1979)[7] reported results of similar models. The following results

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6. For further details the reader may consult, Lefeber and Datta Chaudhari (1964), pp. 112-113.

7. Palaniswamy, S.P., and S. Gangopadhyay, Technological Forecasting in Transportation (A Delphi Study), NCST Panel on Futurology, Mimeographed, May 1979, p.116.

are pertinent.

$$\text{Ln } T = 0.37 + 0.84 \text{ Ln } Y_I , \quad R^2 = 0.98$$

$$\text{Ln } T = -0.75 + 1.42 \text{ Ln } Y_A , \quad R^2 = 0.76$$

where T = index of rail freight traffic in tonne-kilometres with base year 1950-51.

Y_I = index of industrial production.

Y_A = index of agricultural production.

We note that the estimated elasticities are far more satisfactory.

On the other hand, Parikh's (1980)[8,9] estimates of freight traffic gave the following result:

$$\text{Ln } T = \text{constant} - 1.46 \text{ Ln } X_1 + 1.10 \text{ Ln } X_2 , \quad \bar{R}^2 = 0.96$$

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8. Parikh, J.K., Modelling Approach to the Long-Term Energy Demand and Energy Policy Implications (New Delhi: Government of India, Planning Commission, June 1980).

9. On the basis of a linear regression relation between tonne-kilometres of goods carried by the Railways (T) and the real GNP originating outside agriculture (X_1), stock of Trucks (X_2) and a time trend (X_3), Parikh and Srinivasan (1977) reported the following:

   $$T = 3387 + 13.40 X_1 - 0.33 X_2 + 3940 X_3 , \quad R^2 = 0.98$$

   See, Parikh, K.S., and T.N. Srinivasan, Food and Energy choices for India (Laxenburg : IIASA, 1977), p. 8.

where

T = net tonne-kilometres.

X_1 = fraction of urban population to total.

X_2 = gross domestic product in industries (Rs. 10^9.).

Observe that the coefficient of X_2 is acceptable for forecasting purposes though it is relatively high and may overestimate freight movements. Further, the negative effect of X_1 signifies the fact that much of the manufacturing activity has a tendency to be concentrated in urban areas thus reducing the need for freight movements.

In his study of cross-sectional data for various states Pathak (1976) considers the demand for truck transport to depend on the industrial and agricultural components of income, road density and broad gauge railway density in the state.[10]

It may now be pointed out that in most of the Indian studies a log-linear form has been used and has been found satisfactory. On the other hand, Parikh and Srinivasan (1977) and Rakowski (1976) found linear forms to be more appropriate.

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10. In Pathak (1980, p.21) he indicated that the detailed study had been done elsewhere. We could not get adequate details of the quantitative study even on personal communication.

However, it has not been possible to identify the reasons for the differences especially because there is no theoretical basis for these studies. We will return to this issue in the next section.

The following general observations on such models will now be relevant: (a) They are too naive even as forecasting devices and do not have any theoretical basis. (b) Even as ad hoc specifications there has been no comprehensive attempt to systematically test the various factors which may conceptually be expected to have an influence on freight movements. (c) There has been no attempt to verify the extent to which these models were actually able to withstand the rigours of forecasting for which they were originally intended.[11]

2.3 GRAVITY MODELS

The most popular among the models of freight movements has been the gravity model formulation. Such models are usually designed to examine interregional flows. The basic proposition underlying the gravity models, in all their variations, is that the flow of goods between any two regions

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11. Palaniswamy and Gangopadhyay (1979) presented short-term forecasts. They also have forecasts for the year 2000. But model validation is not explicitly attempted.

is directly proportional to the supply at the origin, the demand at the destination and is inhibited by the impedance due to their spatial separation. Thus a simple gravity model can be mathematically formulated in the following manner:

$$Tij = K \frac{Yi\ Dj}{dij}$$

where

Tij = traffic flow from i to j .

Yi = production at origin i .

Dj = demand at destination j .

dij = distance between i and j .

K = a constant of proportionality.

This model has been originally introduced into the literature as an extension of the passenger trip distribution analysis where its efficacy as a forecasting device has been well-established. The basic motivation for all gravity model formulations is the analogy with the inverse square law of physics.

However, there have been several attempts to develop a satisfactory economic theory which can generate the gravity model. Prominent among these attempts are the studies of Niedercorn and Bechdolt (1969), Wilson (1970), and Anderson

(1979)[12]. This aspect is in contrast to the ad hoc models of the earlier section.

Several practical difficulties have been noticed in the use of such models. For instance, it may not be adequate to represent the impedance by the distance measure alone. Alternative formulations, in which freight rates and more general measures were adopted, are also found in the literature. The second, and equally important from an empirical point of view, is the specification of the constant K. One of the constraints on the freight movements originating from i is the fact that their total cannot exceed Yi. As a consequence, the constant K depends on the index i and can be verified to take the value $Ki = \sum_j (\frac{dij}{Dj})$. With this modification the

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12. (i) Niedercorn, J.H., and B.V. Bechdolt, Jr., An Economic Derivation of the "Gravity Law" of Spatial Interaction, Journal of Regional Science, August 1969, pp. 273-282.

(ii) Wilson, A.G., Entropy in Urban and Regional Modelling (London: Pion, 1970).

(iii) Anderson, J.E., A Theoretical Foundation for the Gravity Equation, American Economic Review, March 1979, pp. 106-115.

resulting formulation is referred to as the production constrained gravity model. See, Black (1972).[13]

In most of the studies of recent vintage[14], where gravity model formulations are used, we find a basic change.

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13. Black, W.R., Interregional Commodity Flows: Some Experiments with the Gravity Model, Journal of Regional Science, April 1972, pp. 107-118.

14. Refer to the following:

    (i) Sloss, J., The Demand for Inter-City Motor Freight Transport - A Macroeconomic Analysis, Journal of Business, January 1971, pp. 62-68.

    (ii) Hutchinson, B.G., Estimating Urban Goods Movement Demands, Transportation Research Record, 1974, pp. 1-15.

    (iii) Chung, C.C., and P.O. Roberts, Design of a Structure and Data Analysis Scheme for Inter-City Freight Demand Forecasting, M.I.T., C.T.S., Report No. 75-15, September 1975, pp. 16-49.

    (iv) Hariton, G., et. al, Econometric Forecasting - Demand for Freight Transport in Canada, Canadian Transport Commission, Report No. ESAB-76-16-5, June 1976a, pp. 8-17.

    (v) Hariton, G., Zohar, U., Le, C.D., and R.S.H. Lee, Demand for Freight Transportation in Canada, International Journal of Transport Economics, August 1976b, pp. 49-62.

    (vi) Ogden, K.W., The Distribution of Truck Trips and Commodity Flow in Urban Areas: A Gravity Model Analysis, Transportation Research, April 1978, pp. 131-137.

    (vii) Pitfield, D.E., Freight Distribution Model Predictions Compared : A Test of Hypothesis, Environment and

contd...

To begin with notice that a gravity model is difficult to estimate since the values of parameters attached to Yi, Dj and dij have been apriori specified to assume a value unity. Hence, any empirical verification of the gravity model encounters problems of defining the measure of goodness of fit.[15] Secondly, and most analysts would consider this to be much more fundamental, there is no apriori theoretical justification for considering all the exponents to be unity. In fact, the hypothesis can be tested by conventional econometric methods if we adopt the following alternative specification:

$$Tij = K \quad Yi^{a_1} \quad Dj^{a_2} \quad dij^{a_3}$$

where a_1, a_2 and a_3 are parameters to be estimated. It may be recalled that the theoretical framework of Anderson (1979) in fact found justification for such a specification.

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14. (contd...)

    Planning A, July 1978, pp. 813-836.

    For an exhaustive review of these models one may refer to Chung and Roberts (1975) and Daughety, A.F., Inaba, F.S., and T. Zlatoper, Demand for Freight Literature Review, North-western University, Working Paper No.601-76-04, May 1976.

15. For a discussion of issues related to this and some possible measures, see Pitfield (1978).

In most of the gravity model formulations the length of haul or the distance factor is assumed to be given exogeneously. On the contrary, we found in chapter 1 that there are significant empirical reasons to believe that it is subject to choice by the shippers. Theoretically this is one of the shortcomings of the gravity model formulation.

The empirical performance of the gravity models has not been outstanding in any case. As early as 1975, Smith provided evidences "that such models are unsuitable for more practical forecasting purposes" - p.317. The more recent analysis of Pitfield (1978) has been equally discouraging. He summed up the evidence in the following terms: "The commodities best modelled by the gravity model are other earth and stones; coal and coke products; bricks and other building materials; steel; and cement. ... The worst predictions are for furniture, textiles and shoes; vehicles... plastics; gases, acids, and bulk chemicals; and electrical equipment; ... there is no obvious explanation for the difference in model performance; the gravity model does not seem to yield better predictions for nonhomogeneous commodities". - p.825. Despite some such negative evidences, as Oum (1979)[16] puts it, these models have been reasonably

16. Oum, T.H., Derived Demand for Freight Transport and Inter-Modal Competition in Canada, Journal of Transport Economics and Policy, May 1979, pp. 148-168.

successful in forecasting short-run demand for freight movements.

The most common criticism of the gravity models is that they do not clearly spell out the structure of shipper preferences which give rise to these derived demand equations.[17,18]

In particular, the sensitivity of freight movements to variations in the price of output has not been studied adequately.[19] However, Nazem (1979)[20] expressed the role of output prices on freight flows clearly. Firstly, a higher output price at the market destination is necessary to induce a shipper to move greater distances in search of markets. Secondly, a higher price obtainable for a commodity

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17. The necessity for a behavioural basis has also been emphasized by:

    (i) Allen, W.B., The Demand for Freight Transportation: A Micro Approach, Transportation Research, February 1977, pp. 9-14.

    (ii) Daughety, A.F., and F.S. Inaba, Estimating Service-Differentiated Transport Demand, Transportation Research Record, 668, 1978, pp.23-30.

    (iii) Hutchinson (1974).

18. Wilson and Taneja (1979) also pointed out the lack of policy orientation in existing models, see, Wilson, L.B., and N.K. Taneja, Disaggregate Mode-Share Models for Air Freight Analysis, Transportation Research, April 1979, pp. 115-123.

19. This has been observed by Oum (1979) among others.

20. Nazem, S.M., Entropy of Freight Transportation and

(contd ...)

is a sufficient condition since it enables the shipper to cover the transport cost.

Such an expression of shipper behaviour indicates that behavioural models of shipper decision based on micro-economic theory of the firm are more promising. In fact, a substantial literature has already developed along these lines. We must now turn to these considerations.

2.4 BEHAVIOURAL MODELS

A few models of recent vintage deal with micro-level analysis of the behaviour of shippers. We will review the more important studies in this section.

For instance, the Baumol and Vinod (1970)[21] study is basically an inventory theoretic approach. They consider the choice of quantum shipped by balancing the shipping costs, total in-transit carrying costs, ordering costs and the inventory carrying costs at the destination. The resulting expression for the quantum shipped varies directly with the volume of demand, warehousing costs at the destination and

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20. (contd..) Price Variation, European Journal of Operations Research, September 1979, pp. 413-416.

21. Baumol, W.J., and H.D. Vinod, An Inventory Theoretic Model of Freight Transport Demand, Management Science, March 1970, pp. 413-421.

inversely with the cost of ordering and processing per shipment. Two observations are in order: (a) It is not altogether plausible that the total volume of freight movements should increase with warehousing costs, and (b) the volume shipped is independent of the transit time. One of the reasons for this result is the assumption that the transit carrying cost per unit of time is independent of the transit time. In actual fact, an increase in the length of haul has the effect of increasing the transit time and transit carrying costs would therefore depend both on the transit time and volume of shipments. But such generalizations have not been attempted. Instead, Baumol and Vinod consider the modal choice problem by explicitly incorporating the differences in freight rates, speed, dependability and enroute losses.

In a somewhat loosely defined behavioural model of mode choice in freight movements, Boyer (1977)[22] estimated modal shares as a function of relative prices, length of haul, tonnage shipped by all modes, value per ton of the goods carried and other pertinent variables. Both the relative prices and total tonnage were statistically

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22. Boyer, K.D., Minimum Rate Regulation, Modal Split Sensitivities, and the Railroad Problem, Journal of Political Economy, June 1977, pp. 497-512.

significant in the empirical studies of Boyer.

The most theoretically satisfactory approach to behavioural models of freight movements has been that of Allen (1977). He developed a demand function for freight movements adopting neo-classical models of profit maximizing behaviour. We outline the following simplified special case to illustrate the pertinent analytical elegance of Allen's work. Let a firm produce a quantity Q of output at location A and sell it at two locations: the homebase and market at a distant location B. Let S be the quantum sold at B and let the price per unit at B be denoted by P_b. Then (Q-S) will be sold at A and let price per unit at A be P_a. Let the cost of shipping each unit of output be considered as a function of the volume of shipment and time taken in transit. We denote it by ACS = average cost of shipment = $a S + b\alpha$, where α is the transit time. The firm can then be viewed as choosing S so as to maximize profits. That is, choose S to maximize

$$\pi = P_a (Q - S) + P_b S - a S^2 - b S \alpha$$

Explicit optimization results in the specification of the quantum of shipment as

$$S = (P_b - P_a - b \alpha) / 2a$$

This quantity is affected by the price differentials, transit carrying costs and transit time.

Allen explicitly pays attention to the present values of gains by discounting the revenues earned at B. He also considers the effect of shipments and transit times on the production decisions of firms. Models of this nature have also been developed by Miller and Jensen (1978)[23] under slightly different assumptions. But the essential aspects of analysis are adequately represented in the simplified exposition that we have offered.

The following observations are important. (a) Given the choice of market location B, the firm has only a mode choice as reflected in the variability of α. Hence, Allen visualizes his models as basically descriptions of modal choice for a given market centre. However, if we restrict the problem to a single mode, then the choice of α would be the same as the choice of length of haul allowing location B to vary. Of course, it is quite evident that by suitable adjustments α can be made to reflect both these effects. Such analytical extensions are straight forward and do not

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23. Miller, S.M., and O.W. Jensen, Location and the Theory of Production, Regional Science and Urban Economics, May 1978, pp. 117-128.

invalidate any of Allen's fundamental results.

The most comprehensive extensions of Allen's work have been the studies of Daughety and associates.[24] They view freight service demand to originate from the spatial distribution of production centres and markets. Their models "allow for mode and market choice based on prices at the markets, transport rates, and service characteristics."

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24. (i) Daughety, A.F., and F.S. Inaba, Empirical Aspects of Service- Differentiated Transport Demand, Motor Carriers Economic Regulation, Proceedings of Workshop sponsored by the National Academy of Sciences, April 1977.

(ii) Daughety, A.F., and F.S. Inaba, Modelling Service-Differentiated Demand by Freight Transportation: Theory, Regulatory Policy Analysis, Demand Estimation, Proceedings of National Symposium on Transportation for Agricultural and Rural America, U.S. Department of Transportation, August 1977.

(iii) Daughety, A.F., and F.S. Inaba (1978).

(iv) Daughety, A.F., Freight Transport Demand Revisited: A Micro Economic View of Multimodal, Multi-Characteristic Uncertainity and Demand for Freight Transport, Transportation Research, December 1979, pp. 281-288.

(v) Daughety, A.F., and F.S. Inaba (to appear in 1981).

In their more recent studies they are even considering the decision regarding the "markets to ship to" or what we are referring to as the length of haul. The resulting demand equations reflect the choice of mode, market prices, and other service characteristics.

We consider these studies to be the most satisfactory behavioural approaches to a study of freight movements. The relationship of our models to these results will become clear in the sequel.

In a somewhat alternative formulation of behavioural models, Levin (1978)[25] developed a utility maximising approach. The only interesting difference, in contrast to Allen (1977), is a choice among a discrete and finite set of modes. Such quantized formulations require estimation using multinomial logit models.

The study of Oum (1979) also represents a somewhat distinct fundamental contribution to a behavioural approach to freight movements. He approaches the problem by considering freight flows as one of the inputs in a production function. He explicitly derives the demand for transport services on

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25. Levin, R.C., Allocation in Surface Freight Transportation: Does Rate Regulation Matter?, The Bell Journal of Economics, Spring 1978, pp. 18-45.

different modes as derived demand functions of neo-classical production theory. To that extent, we have a more theoretically sound approach than that of Rao (1978a,b,c)[26] and Rao and Sparks (1978)[27]. The work of Friedlaender and Harrington (1979)[28] is also similar to the work of Oum (1979) in its theoretical perspective.

By and large we feel that the behavioural models, based on microeconomic theoretic considerations, have been able to offer the most convincing insights from an empirical perspective as well.

2.5 CONSIDERATION OF THE LENGTH OF HAUL

It may be noted that in all the above studies, the consideration of the length of haul is conspicuous by its

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26. Rao, P.S., A Short-Run Disaggregated Model of Rail Freight Demand for Canada, Logistics and Transportation Review, 1978b, pp. 23-54.

    Rao, P.S., The Impact of Structural and Compositional Changes on the Canadian Railway Industry 1958-1973, Transportation Research, April 1978c, pp. 79-82.

27. Rao, P.S., and G.R. Sparks, Econometric Forecasting of Railway Freight Demand, Canadian Institute of Guided Ground Transport, Report No.78-4, December 1978.

28. Friedlaender, A.F., and I. Harrington, Intermodalism and Integrated Transport Companies in the United States and Canada, Journal of Transport Economics and Policy, September 1979, pp. 247-267.

absence. Lefeber and Datta Chaudhari (1964) clearly emphasized the need to differentiate between the demand for distance moved from tonnage to be handled. As they put it: "In transportation planning both must be separately considered since capacity adjustment for increased lead (given tonnes) is not equivalent to adjustment for increasing tonnage (given lead)". However, they did not explicitly model this aspect of the problem.

Ogden (1977)[29] provided a few observations on a purely empirical basis. He considers the length of haul to be primarily determined by the locations of production centres and destinations.

Rao (1978a) developed a systems model in which the tonnage moved and the length of haul are related to certain structural as well as price variables. However, there are many difficulties with this model. For one thing, the specification is not based on any explicit theoretical considerations.[30] Secondly, it is not altogether clear that

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29. Ogden, K.W., An Analysis of Urban Commodity Flow, Transportation Planning and Technology, 1977, pp. 1-9.

30. In fact Rao (1978a) developed a cost function from a behavioural basis in the Appendix. But we do not find any behavioural basis for determining the length of haul and quantum of shipments.

the inclusion of the length of haul as an endogeneous variable has any purpose.

We therefore conclude that there is, as yet, the need to develop a behavioural model of freight movements which explicitly traces out the variables affecting the choice of the quantum shipped and the length of haul.

2.6 CONCLUSION

Recall that while reviewing the literature on freight movements we had the following major purpose: to obtain guidelines from the existing literature as to what pertinent aspects will have to be considered and how a theoretically satisfactory model can be developed to study the length of haul and quantum of shipments in freight movements. We may sum up our experience in the following manner: (a) the behavioural models based on microeconomic theory would be the most appropriate, (b) there is as yet no clear behavioural basis for consideration of length of haul, and (c) the behavioural models available in the literature will have to be extended appropriately to accomodate considerations of length of haul.

Given the very recent growth of these studies it should not be surprising that a fundamental breakthrough is necessary. We will attempt to provide one such modelling exercise in the next chapter.

CHAPTER 3

THE ANALYTICAL FRAMEWORK

3.1 INTRODUCTION

It is by now apparent that our primary problem is to develop a framework within which we can examine the behaviour of the shipper's decisions regarding the quantum of freight moved and the length of haul. When this framework is available the second task would be to set up an analytical framework which establishes the linkage between these variables and the supply of and demand for wagons in terms of which we have to ultimately measure the railway services. The present chapter will be devoted to a study of the requisite theoretical formulations.

3.2 DYNAMICS OF FREIGHT FLOWS

We noted in the previous chapter that the existing models of freight movements postulate a static equilibrium in which (a) the locations of firms in an industry are fixed, (b) the total demand for the products, in each of the predefined set of markets, is fixed, and (c) all relevant prices are fixed. Under these assumptions if we postulate that the traffic managers of each firm maximize profits, they will have choices of destination, shipment size and transport

mode.

However, in a dynamic phase of the economy, the markets are in a state of continuous flux. There is an increase in the demand for goods at the existing markets as well as an emergence of new market centres. Typically, such increases in demand do not bring about a growth of new firms and/ or location of branches of existing units until a considerable amount of time elapses. At least over a medium run of time horizon it may be more economical to increase the quantum shipped from the existing locations. Only when we consider a relatively longrun horizon of time would it be realistic to consider the location of firms, their production plans, and freight flows to be interrelated.

We therefore propose to make an attempt to extend the micro-level theory of firm to include the length of haul and quantum shipped. We adopt the framework of Allen (1977) with requisite modifications. The methodology will be shown to be sufficiently general so as to encompass both the movements of final goods and raw materials and can also be extended to include modal choice.

3.3 MODELLING FRAMEWORK: FINAL PRODUCT SHIPMENT

For purposes of simplicity of exposition, we consider the case of shipment of final products to begin with. Let

us simplify the analysis further by considering the case of a firm located at A and a market at B (not fixed) which is at a distance L along a straight line. We will postulate that the raw materials required for production are available at A itself.

We will make the following assumptions as well: (a) the transport costs are usually small enough relative to the costs of producing a given amount of output. Hence, the production decision can be taken to be independent of freight rates. We therefore assume that the volume of production of a firm is given exogenously. Obviously such an assumption is convenient in so far as it enables us to concentrate on the transportation problem. (b) there are two markets for the output. One is at location B and the other is the homebase A.

We denote by S the quantity shipped to market B. (Q-S) then denotes the sale at A. The market at A is described by the following demand curve: price per unit of sales at A = $p\,J(Q-S)$; $J_1 < 0$ where p is the average industry price and J_1 denotes the derivative of J with respect to its argument (Q-S). Since location B is not fixed, but is postulated to be at a distance L from A, we will approximate price per unit of sales at B = $p\,f(L)\,h\,(S)$; $f_1 > 0$, $h_1 < 0$ indicating thereby that the economic incentive

for shipping out i. the lure of obtaining higher prices.

This specification necessitates some further explanation. To start with, let us note that this is not being considered as the response of the consumers at location B. We can only postulate that $p^{*}h(S)$ will be the price they are willing to pay. However, from the viewpoint of the shipper, the market at B becomes attractive only because the price differential enables him to derive a profit. He therefore visualizes $p^{*} = pf(L)$.

We will then acknowledge that the economic advantage is derived at a cost. This is basically the transport cost. Let us denote the transport cost per unit = $tg(L)$; $g_1 > 0$ postulating that the transport rates are dependent on the length of haul[1]. The profit function for the firm then becomes[2]

$$\pi(L,S) = pJ(Q-S)(Q-S) + pf(L)\,h(S)S - tg(L)\,S$$

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1. Morlok (1979) noted that there can be cases of decreasing user costs with an increase in the volume of shipments. This phenomenon is observed in transport modes which are demand responsive. To the extent that the railways are also making attempts to eliminate empty haulage of wagons, as far as practicable, marginal transport costs may decrease with an increase in S. We are not however aware of any empirical evidence of this phenomenon in the Indian context. See, Morlok, E.K., Short Run Supply Functions with Decreasing User Costs, Transportation Research, September 1979, pp.183-187.
2. Since costs of production have no effect on the decisions being considered we are not specifying it explicitly. Hence, p may be treated as a price- cost margin. With this interpretation p can be viewed as a function of Q to obtain a higher level of generality.

We now assume that the firm chooses L and S so as to maximize short run profits. We thus have the first order conditions

$$ph\, f_1 = t\, g_1 \qquad - (1)$$

$$p\, J\left(1 - \frac{1}{\eta_1}\right) = phf\left(1 - \frac{1}{\eta_2}\right) - tg \qquad - (2)$$

where η_1 and η_2 are elasticities of demand in markets A and B respectively.

Equations (1) and (2) together determine the optimal choice of L and S. To analyze the nature of the choice explicitly, we proceed as follows: Denote

$$E_1 = ph\, f_1 - t\, g_1 \text{ , and}$$

$$E_2 = pJ\left(1 - \frac{1}{\eta_1}\right) - p\, f\, h\left(1 - \frac{1}{\eta_2}\right) + tg \qquad - (3)$$

To begin with observe that both the optimal choices, viz., those of L and S depend on p, t and Q. The nature of the functions can be developed as follows:

$$\frac{\partial E_1}{\partial L} = ph\, f_{11} - tg_{11} \text{ , and}$$

$$\frac{\partial E_2}{\partial L} = ph\, f_1 \frac{1}{\eta_2} \qquad - (4)$$

in view of equation (1).

We have to consider the sign of f_{11} at this stage. We normally expect prices to increase with L. However, a given firm, operating from a location such as A, experiences pressure of competition as it tries to penetrate into markets which are further away from its home base.[3] Thus, price increases will be subject to decreasing rates resulting in a negative sign on f_{11}.

It would be descriptively realistic to consider two alternative specifications of g_{11}. (a) Marginal costs are increasing at an increasing rate, i.e., $g_{11} > 0$. We expect that the transport rates will reflect increasing marginal costs under normal working of the market forces. (b) When rate tapering is in operation we find that $g_{11} < 0$.[4]

We have therefore to determine the sign of $tg_{11} - phf_{11}$. We may again distinguish two cases. (a) Transport costs

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3. The empirical evidence offered by Maejima (1979) supports this viewpoint. See, Maejima, T., An Application of Continuous Spatial Models to Freight Movements in Greater London, Transportation, 1979, pp. 51-63.

4. It is often said that railroad freight rates, and indeed the rates of other modes as well, tend to taper. This means that instead of increasing directly in proportion to distance moved, rates increase at a decreasing rate.

increase faster than revenues as the length of haul increases. We therefore expect $tg_{11} - phf_{11} > 0$. (b) Over a medium term time horizon the firms have a monopoly advantage in catering to expanding markets so that we may have a case in which $tg_{11} - phf_{11} < 0$. Both these cases will have to be considered while examining the choice of L and S.

We now examine the locus of $E_1 = 0 = E_2$ in the (L, S) plane. Consider the expressions E_1 and E_2 from (3). Observe that from $E_1 = 0$ we get

$$\frac{dS}{dL} = \frac{tg_{11} - phf_{11}}{ph_1f_1} \qquad - (5)$$

Similarly from $E_2 = 0$, we have

$$\frac{dS}{dL} = \frac{phf_1 \frac{1}{\eta_2}}{p\ J_1(1 - \frac{1}{\eta_1}) + pfh_1(1 - \frac{1}{\eta_2})} \qquad - (6)$$

Clearly the expression in (5) could be negative or positive since $tg_{11} - phf_{11} \gtrless 0$, while the expression on the right hand side of (6) is negative. Hence, in the (L,S) plane, $E_1 = 0$ locus can be positively or negatively sloped while the $E_2 = 0$ locus is negatively sloped. We could represent them as in Figure 1.

We now analyze the effects of variations in p, t and Q on the length of haul L and the volume shipped S

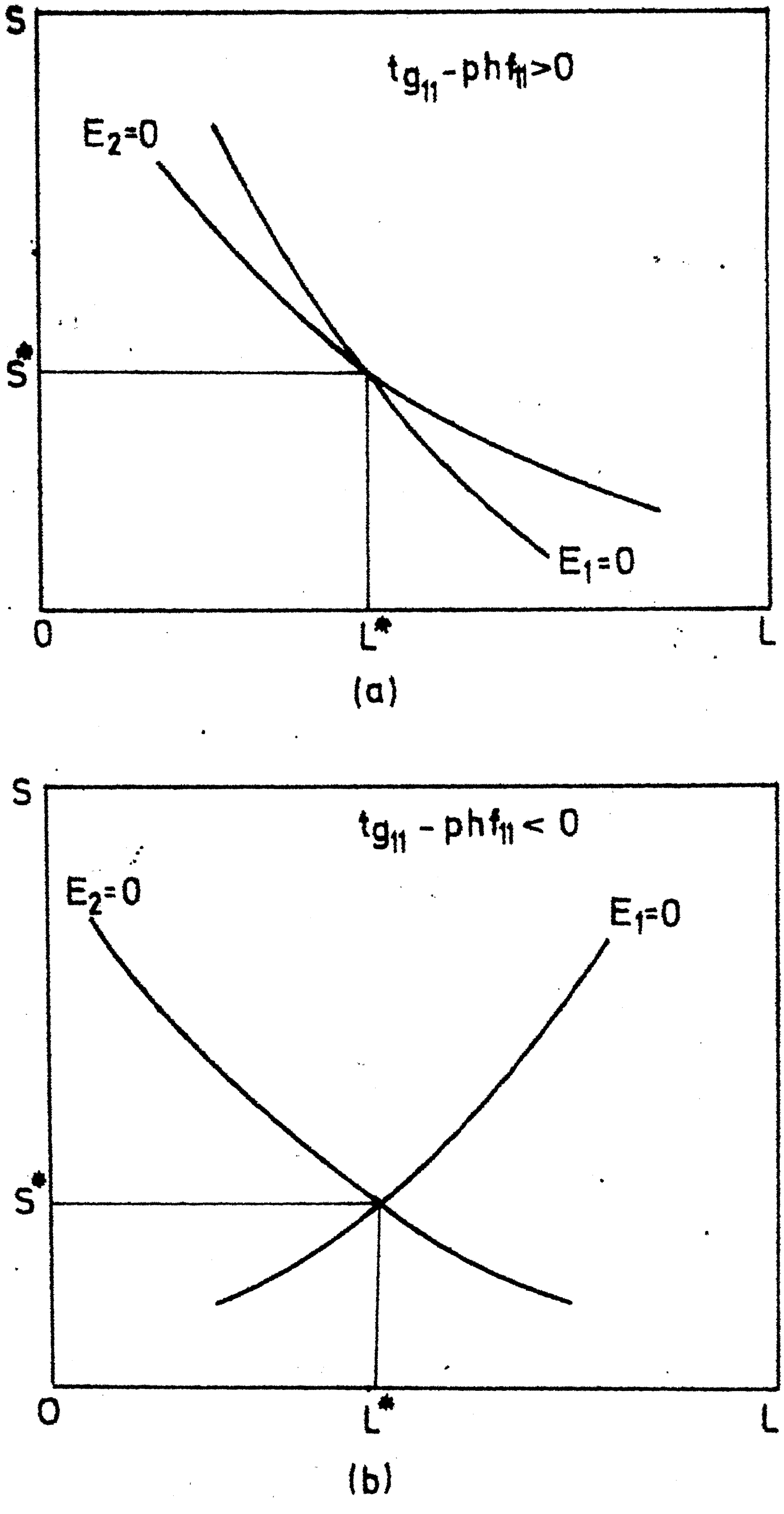

FIG.1 CHOICE OF S AND L

separately.

Variation in p

Recall that

$$E_1 = phf_1 - tg_1 = 0 \text{ , and} \qquad -(7)$$

$$E_2 = pJ(1 - \frac{1}{n_1}) - pfh\,(1 - \frac{1}{n_2}) + tg = 0 \qquad -(8)$$

For any given $L = L^*$, an increase in p would have the effect of changing S. This can be examined in the following manner. Differentiating (7) with respect to p and S we have

$$hf_1 dp + ph_1 f_1 d\,S = 0$$

$$\frac{dS}{dp} = -\frac{h}{ph_1} \qquad -(9)$$

Similarly from (8) , we get

$$\frac{dS}{dp} = \frac{J(1 - \frac{1}{n_1}) - fh(1 - \frac{1}{n_2})}{pJ_1(1 - \frac{1}{n_1}) + pfh_1(1 - \frac{1}{n_2})} \qquad -(10)$$

Clearly, the expressions in (9) and (10) are positive[5].

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5. That the numerator of (10) is negative can be verified as follows:

From (2), we have

$$pJ(1 - \frac{1}{n_1}) - pfh\,(1 - \frac{1}{n_2}) = -tg$$

or

$$\left[J\,(1 - \frac{1}{n_1}) - fh(1 - \frac{1}{n_2})\right] = -\frac{tg}{p}$$

The expression in the bracket is negative.

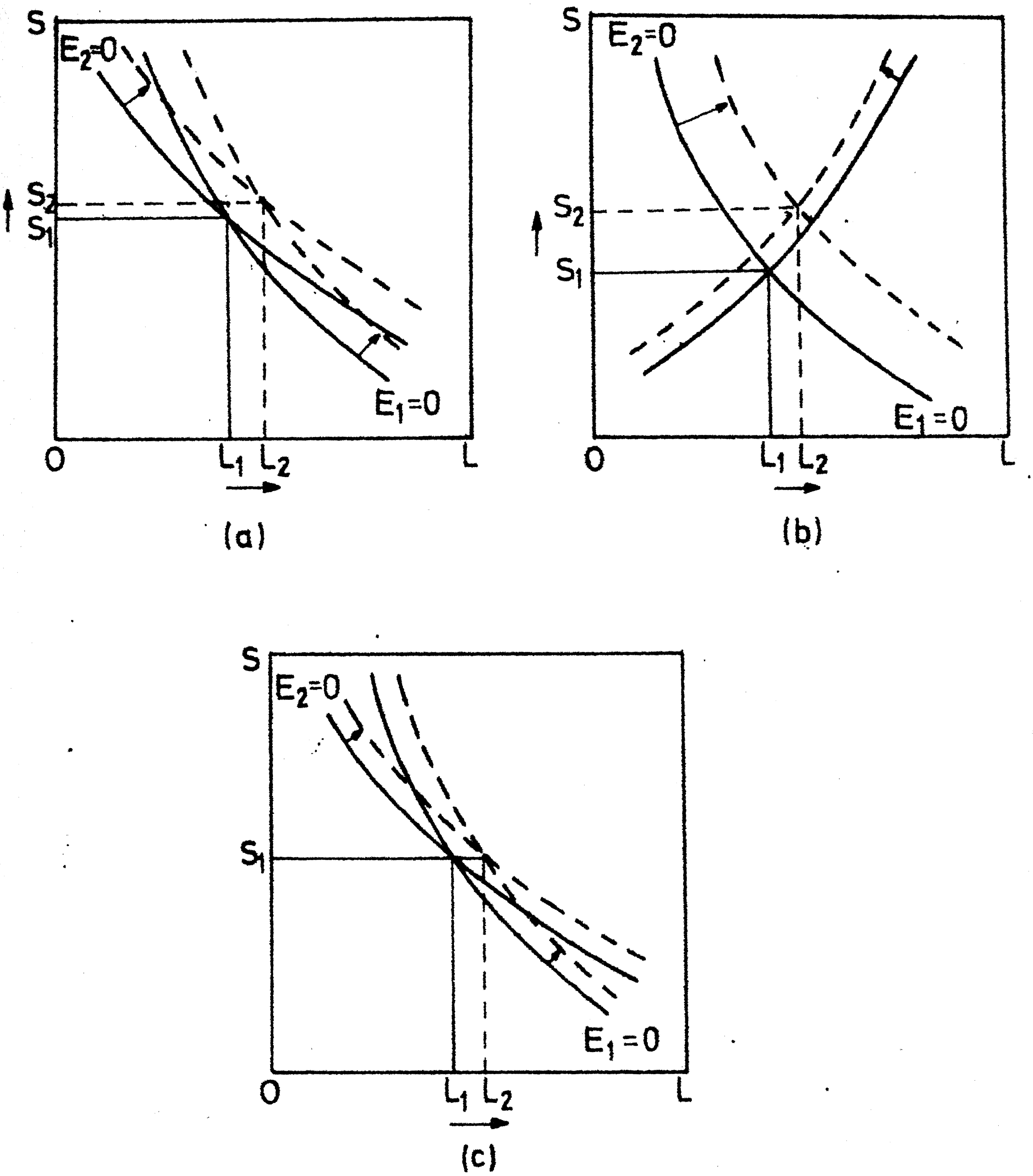

FIG. 2 EFFECT OF VARIATION IN p

The shifts in the two curves are represented in Figure 2. Depending on the extent of these shifts in the (L,S) plane, we would have a variety of configurations of S and L resulting from variations in p.[6] As can be seen from the (a) and (b) panels of Figure 2, we would normally expect S and L to increase with p. In essence, we are saying that as the price of a unit of sales increases, there is an incentive to go further in search of a market and also increase the volume shipped. In panel (c) while L increases with p, S is invariant to changes in p.

Variation in t

The changes in L and S resulting from a change in t can also be obtained in a similar fashion. For, we have from (7)

$$ph_1f_1dS - g_1dt = 0$$

$$\text{i.e.,} \quad \frac{dS}{dt} = \frac{g_1}{ph_1f_1} \qquad - (11)$$

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6. We are confining ourselves to those results which have resulted from empirical experience, as can be seen later. We, however, do not make claim of a unique set of results from the theoretical exercise we have undertaken.

Similarly, from (8) we have

$$\frac{dS}{dt} = \frac{g}{pJ_1(1-\frac{1}{\eta_1}) + pfh_1(1-\frac{1}{\eta_2})} \qquad -(12)$$

The expressions in (11) and (12) are negative. The effects of changes in t on S and L are presented in Figure 3. An increase in transport costs acts as a deterrent to go further distances and even ship more. In panel (c) we have the case of L falling with a rise in t while S is invariant.

Variation in Q

For changes in Q, we derive from (8)[7]

$$pJ_1(1-\frac{1}{\eta_1})\,dQ - pJ_1(1-\frac{1}{\eta_1})\,dS - pfh_1(1-\frac{1}{\eta_2})\,dS = 0$$

$$\frac{dS}{dQ} = \frac{p\,J_1(1-\frac{1}{\eta_1})}{pJ_1(1-\frac{1}{\eta_1}) + pfh_1(1-\frac{1}{\eta_2})} \qquad -(13)$$

The expression in (13) is positive. The resulting shift of the locus of $E_2 = 0$ is shown in Figure 4. In panel (b) the volume shipped as well as the length of haul increase with Q, while in panel (a) the sign is reversed for the length of haul. This reversal can be explained as follows:

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7. E_1 does not shift as Q does not occur in the equation.

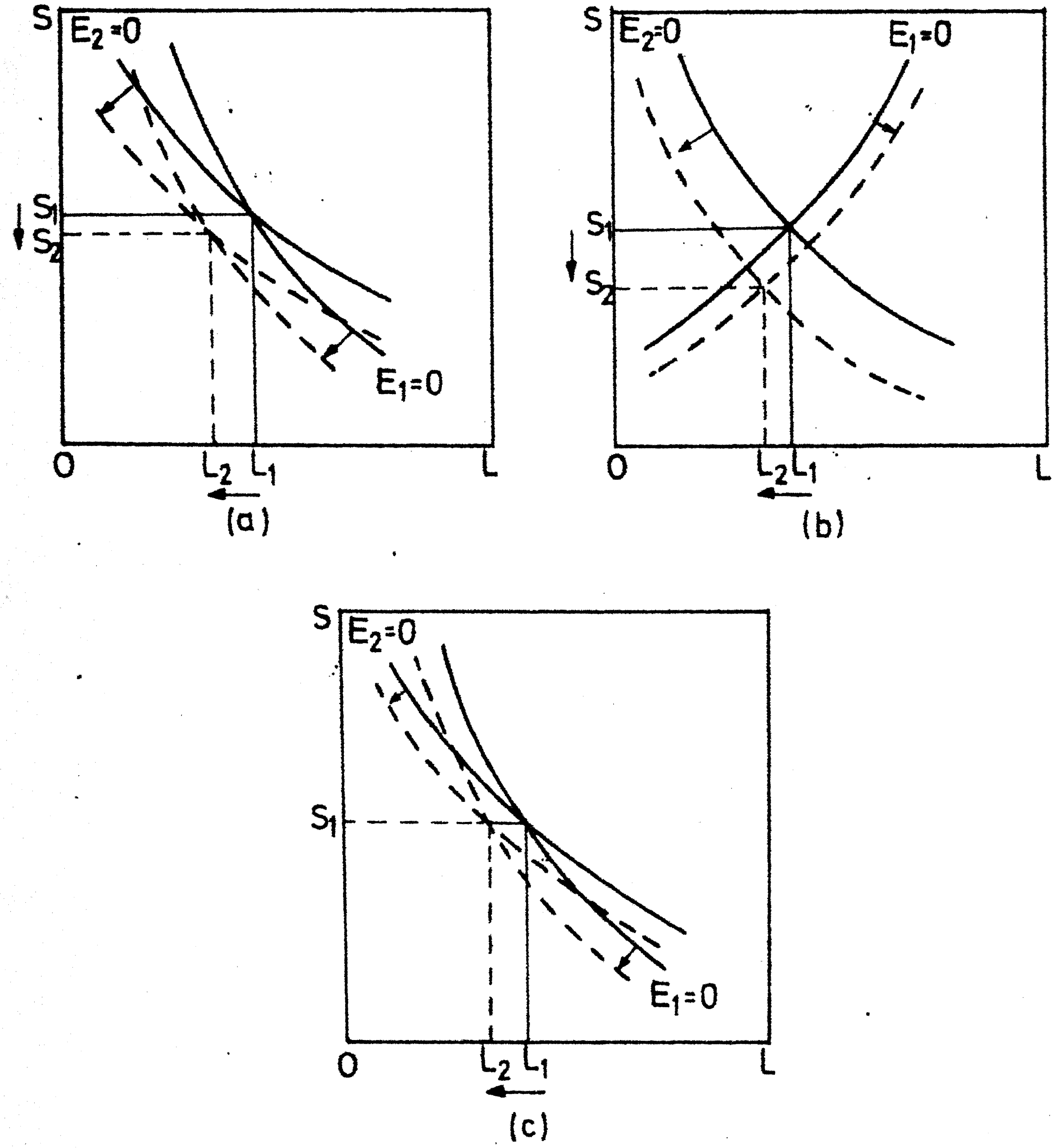

FIG. 3 EFFECT OF VARIATION IN t

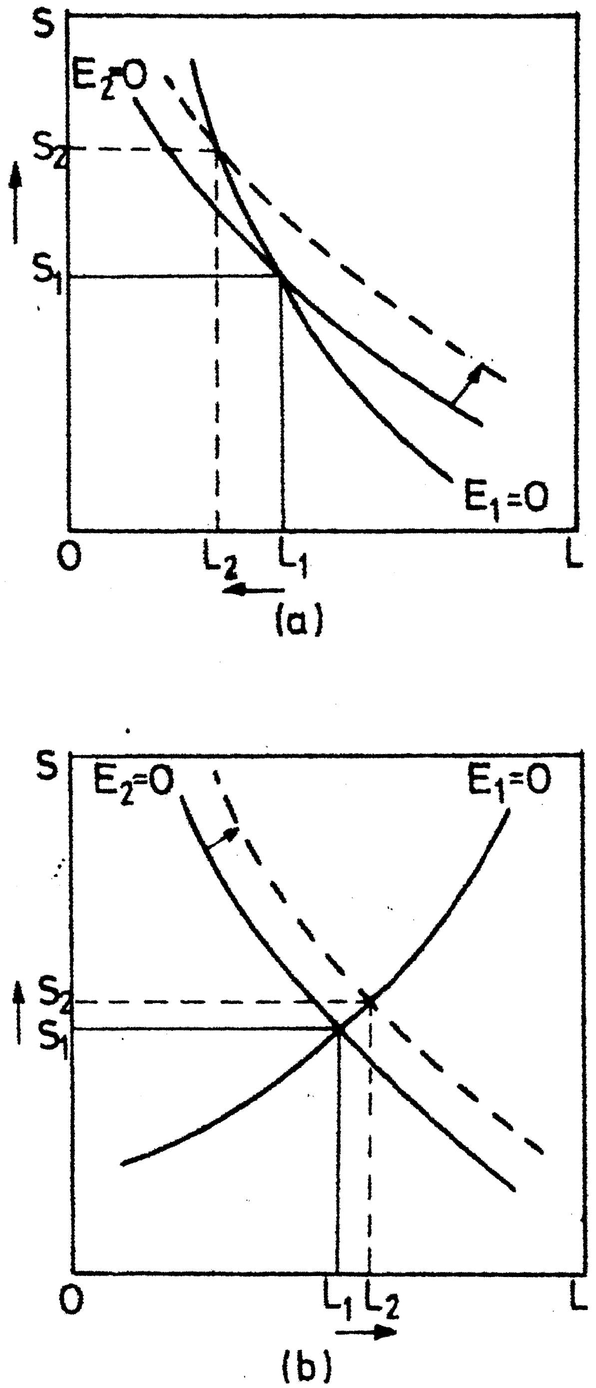

FIG. 4 EFFECT OF VARIATION IN Q

an increase in marginal costs, due to the presence of diseconomies of scale in production, more likely than not reduces the net advantage as represented by p. Under such conditions the advantage in shipping a given distance is reduced and consequently there will be a reduction in L as Q increases.

In sum, we obtain

$$L = L(p, t, Q) ; L_1 > 0, L_2 < 0, L_3 > 0 \qquad - (14)$$

$$S = S(p, t, Q); S_1 > 0, S_2 < 0, S_3 > 0 \qquad - (15)$$

In the introductory chapter it has been observed that there is a distinct possibility of an increase in the length of haul having an effect on the volume of shipments. The possibility of such an effect may now be taken up in the following manner.

Suppose we were to consider the opening of a new market at a greater distance. Provided there is a price incentive, such a market affords an excellent opportunity to the producer to expand his sales. As a consequence, the length of haul would necessarily have to increase in order that the market is reached. But the disincentive that exists is much more than merely the transport costs. For, with an ever increasing length of haul the shipper expects

to encounter the phenomenon of congestion and a deterioration of services. There is thus an implicit cost involved. This tends to dampen the price effect and brings about a fall in the volume of shipments.

There is no rigorous theoretical procedure to establish this proposition. However, for illustrative purposes we may consider the possibility that such speculative activity can be represented by a change in the g function. Quite clearly, a change in the g function may be a result of other external or exogenous disturbances as well. One of the obvious exogenous variations may be the changes in the operating costs of the railways. When such a change occurs both the L and S will be simultaneously affected. This, however, is not the situation we are examining. The external change under consideration increases L through mechanisms other than changes in the g function and the shipper reacts by changing S primarily because of the implicit increase in g he visualizes as a consequence of this change.

As before, the changes in S corresponding to a shift in g can be analyzed in the following manner. Differentiating $E_1 = 0$ with respect to S and g we have

$$ph_1 f_1 dS - t \left(\frac{dg_1}{dg} \right) dg = 0$$

Therefore, $$\frac{dS}{dg} = \frac{t\,\frac{dg_1}{dg}}{ph_1 f_1} \qquad -(16)$$

Similarly from $E_2 = 0$ it can be verified that

$$-\,pJ_1\left(1 - \frac{1}{n_1}\right) dS - pfh_1\left(1 - \frac{1}{n_2}\right) dS + tdg = 0$$

So that $$\frac{dS}{dg} = \frac{t}{pJ_1\left(1 - \frac{1}{n_1}\right) + pfh_1\left(1 - \frac{1}{n_2}\right)} \qquad -(17)$$

The nature of the variation in g_1 with respect to g as reflected in $\frac{dg_1}{dg}$ can be interpreted as follows. If there is an increase in the tariff at all levels of haulage, but the rate structure remains otherwise unaltered, we will have $\frac{dg_1}{dg} = 0$. On the other hand, if as L increases the marginal costs increase at an increasing rate then the rate structure will itself be made progressively steeper. Under such conditions we expect that $\frac{dg_1}{dg} > 0$. This appears to be a more plausible assumption empirically.

We therefore have the expressions in (16) and (17) to be negative. From Figure 5 it can now be verified that the volume of shipments S falls as a result of an exogenous increase in the length of haul.

Such a fall in the volume of shipments gives rise to the speculation that there will be shortages at the

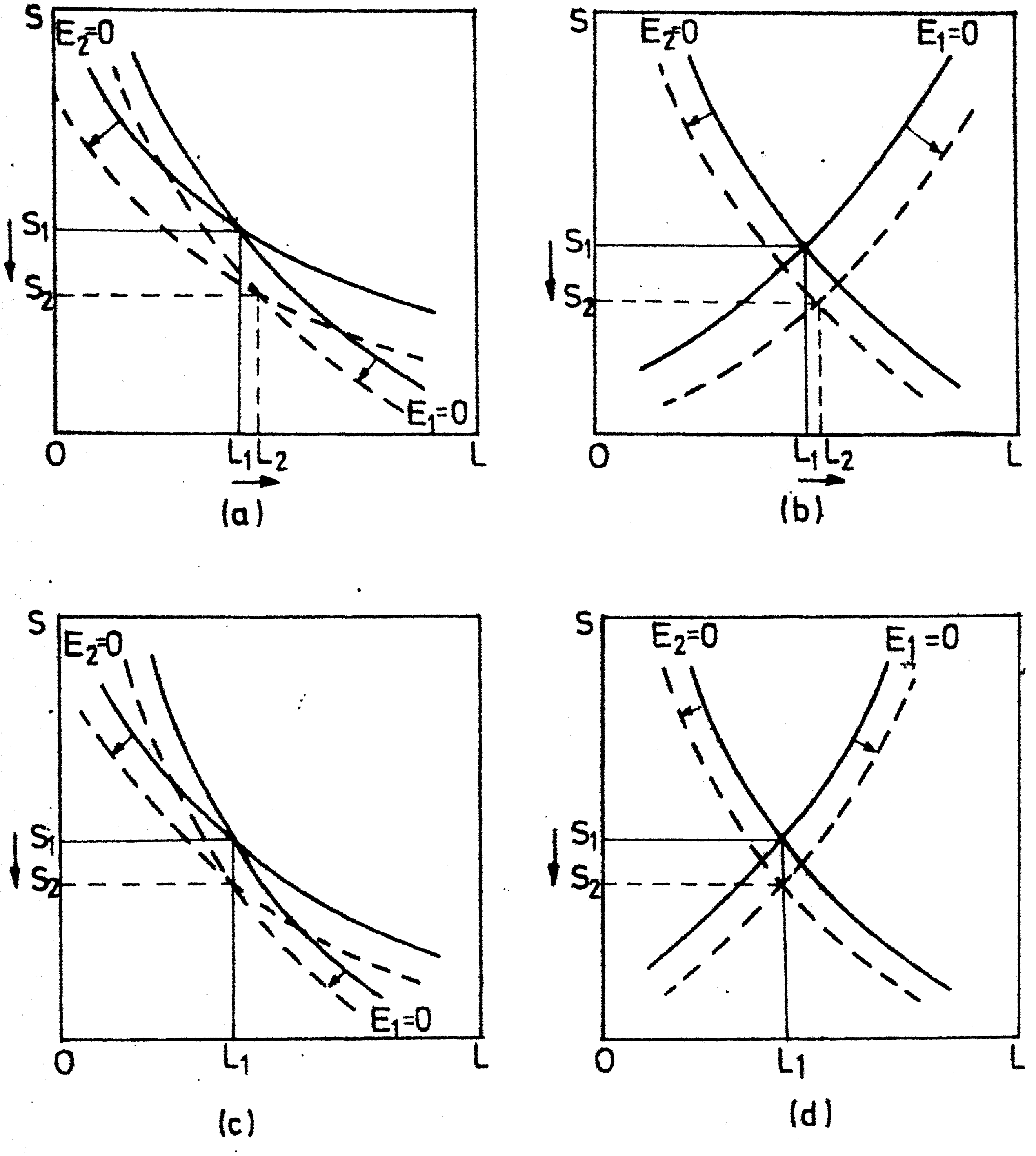

FIG.5 EFFECT OF VARIATION IN g

distant location. Such expectations can be represented by a possible shift in the demand curves. They have the effect of creating a movement in the opposite direction. This can be demonstrated as follows:

From $E_1 = 0$ we have

$$pdhf_1 - ph_1f_1ds = 0$$

$$\text{i.e.,} \quad \frac{dS}{dh} = -\frac{1}{h_1} \qquad - (18)$$

Similarly $E_2 = 0$ yields

$$\frac{dS}{dh} = \frac{-pf\left(1 - \frac{1}{\eta_2}\right)}{pJ_1\left(1 - \frac{1}{\eta_1}\right) + pfh_1\left(1 - \frac{1}{\eta_2}\right)} \qquad - (19)$$

It may then be verified from Figure 6 that the volume of shipments increase as a result of an increase in the length of haul if expectations regarding the shortages and the shifts in h predominate.[8,9]

We therefore have

$$S = S(p, t, Q, L)\ ;\ S_1 > 0,\ S_2 < 0,\ S_3 > 0,\ S_4 \gtrless 0 \qquad - (20)$$

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8. Note that while the increase in length of haul brings about the problem of congestion and speculative activity, these in turn do not affect it. This can be seen in Figures 5 and 6.

9. Artificial scarcities bring about increase in prices.

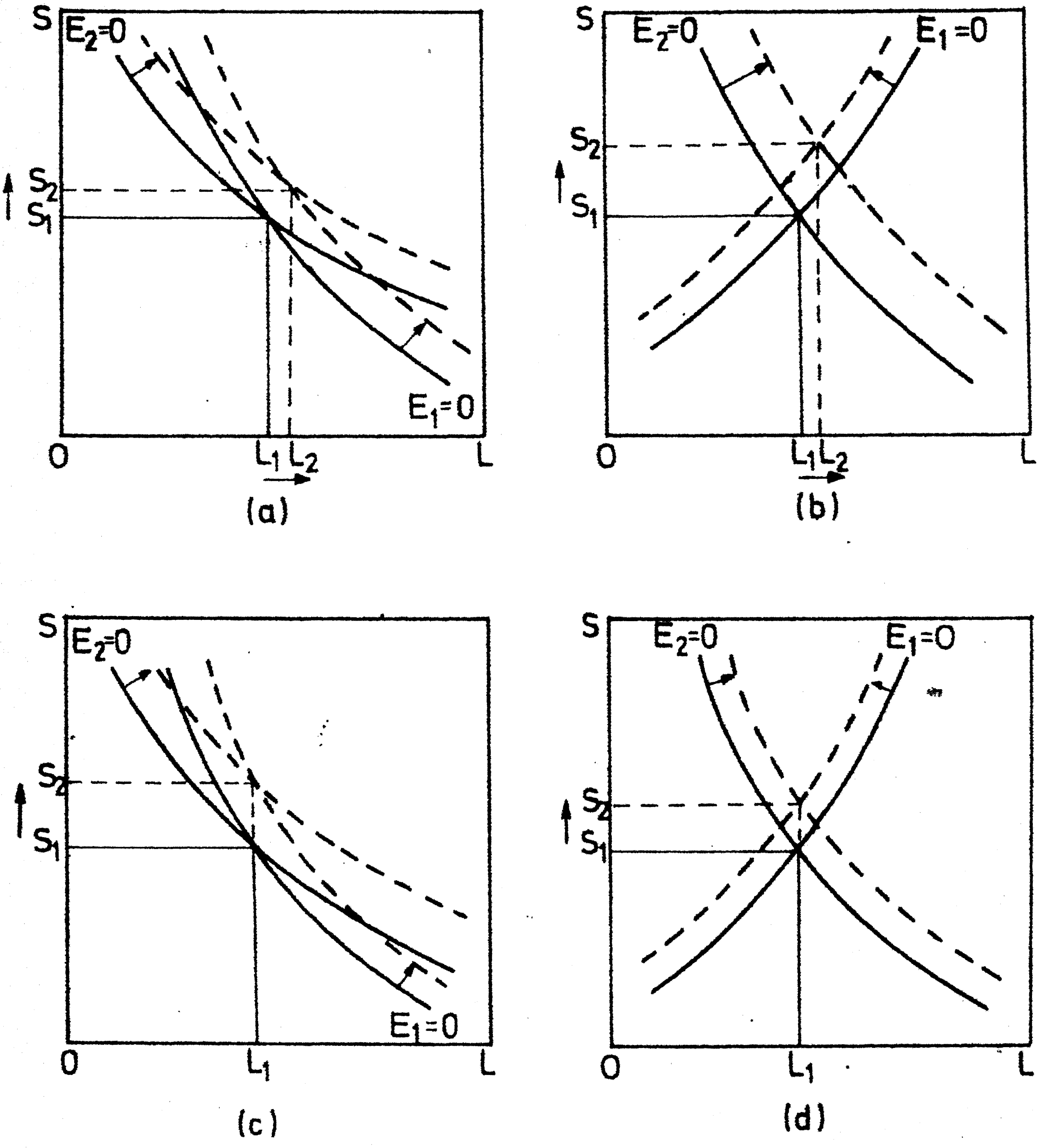

FIG. 6 EFFECT OF VARIATION IN h

Viewed in conjunction with (14) this will give us a recursive system in econometric parlance. It may therefore be estimated by the classical least squares method.[10]

3.4 RAW MATERIAL MOVEMENTS

On occasions, the shipment of raw materials to a central location may be advantageous due to the presence of economies of scale in the production of final output. Let us consider such a case next.

As before, we assume that the production centre for output is at A and that the raw material is available both at A as well as at B (not fixed) at a distance L along a straight line. We abstract from problems of final product shipment by postulating that the market is at A. Once again, we make some simplifying assumptions: (a) the amount Q of the good produced is exogenously fixed, (b) the raw material required to produce a quantity Q of output can be expressed by $R = \alpha Q$ where α is a constant independent of the level of Q, and (c) we denote by S the quantity of raw material obtained from location B. ($\alpha Q - S$) then represents the raw material purchased at A.

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10. See Johnston, J., Econometric Methods (Tokyo: McGraw-Hill Kogakusha, 1972) p. 377.

The price per unit of raw material at A will be described as $rJ(\alpha Q - S)$; $J_1 < 0$ where r is the average industry price. Since location B is not fixed, we will assume that the price per unit of purchases at B can be approximated by $r\,\phi(L)\;\psi(S)$; $\phi_1 < 0$, $\psi_1 < 0$. We are explicitly postulating that lower prices at farther distances constitute the basic economic incentive for shipping raw materials from B.

By constructing the profit function as before and proceeding along similar lines it can be verified that

$$L = L\,(r,\ t,\ Q)\ ;\ L_1 > 0,\ L_2 < 0,\ L_3 > 0$$

$$S = S\,(r,\ t,\ Q,\ L)\ ;\ S_1 > 0,\ S_2 < 0,\ S_3 > 0,\ S_4 \gtrless 0.$$

Virtually all the economic interpretations and qualifications of the earlier case carry over with the necessary changes made by replacing raw material use and its price per unit in place of the product market.[11]

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11. The foregoing analysis can be extended to account for modal choice of the firm in the process of freight movements. We are not presenting the details since the analysis is analogous to the one adopted above.
For details, See, Rao et al, Length of Haul in Freight Movements, International Journal of Transport Economics, to appear in 1981.

3.5 MODELLING WAGON REQUIREMENTS AND WAGON SUPPLY

Our objective in the present section would be to explicitly outline a method of analysis for assessing the demand for services (in terms of requirement of wagons) and the supply of services (in terms of availability of wagons) given the shippers' decisions.

The stock of wagons required to handle a given quantum of shipments over a predefined length of haul may be considered to depend essentially on the average weight which the wagons can carry and the number of trips each wagon can make during a given year. The latter, in its turn, depends upon the length of haul through which a wagon is moving and the efficiency of handling and scheduling of wagons by the railways.

At the present stage of the behavioural theory of freight movements the supply models are as yet grossly inadequate. Hence we could not develop any theoretically satisfactory guideline for actually explaining the variations in the efficiency of handling wagons and other supply characteristics. It will be assumed that the management in this regard is most efficient.

The wagon requirements can be calibrated under the above assumptions in the following manner. Given that a

certain tonnage S is to be moved, the requirement of wagons (expressed as a stock) can be approximated by

$$RW = \frac{S}{(AWL)\,(NTPW)}$$

where

RW = requirement of wagons.

AWL = average wagon load (in tonnes).

$NTPW$ = number of trips per wagon per year.

We now postulate that the number of trips per wagon is an inverse function of the length of haul.[12]

i.e., $NTPW = B/L$

where B = a constant.

L = average length of haul.

Substituting in the earlier equation, we get

$$RW = \frac{S}{(AWL)\,(B)}\,(L)$$

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12. Given the average turnaround time of a wagon, the number of trips a wagon makes in a year on an average is calculated as follows:

$$NTPW = \frac{365 \text{ days}}{TAT}$$

where TAT = turnaround time of a wagon (in days).

Hence, it follows that

$$RW = a_0 SL$$

Where a_0 is a constant.

For purposes of clarity of exposition we reiterate the fact that the RW so defined is in terms of the stock of wagons necessary to handle the quantity S of shipments through an average length of haul L with the usual efficiency of the management.

We define the supply of wagons for any specific commodity group as the stock of wagons which the railways assign to it for handling freight shipments. Defined in this manner the supply of wagons depends upon a number of considerations.

It is generally felt that the railway management prefers an increase in the length of haul partly as a revenue- earning device and secondly as a convenience for handling and management. We will assume that the length of haul which the shippers decide will be automatically accepted by the railways. However, the quantum of freight that the railways are willing (and able) to handle depends upon other criteria.

The two most important aspects which the railways consider in making this decision are (a) the revenue-earning capacity of the shipments of the commodity, and (b) the extent to which wagon use is interchangeable among different uses in a situation of acute shortage. For instance, it is well-known that coal, iron ore and iron and steel are transported in open wagons. Hence, if there is an urgent need to augment the wagon loadings of coal then one or the other of the alternative commodities may experience a reduction in the supply of services. We now consider the specification of the supply of wagons on these two criteria.

To begin with postulate that a constant fraction of the available wagon stock is alloted to a specific commodity. The revenue earned by each of the wagons so channeled depends upon (a) the length through which it is hauled on an average, and (b) the number of times it is loaded. The former reflects the effect of the rate structure and the latter the turnaround time of wagons. Apriori we expect that while the former increases revenue the latter reduces it. In addition, since a given rate of increase in the length of haul does not increase the rate of change of the freight rates by as much as the resultant rate of increase in turnaround time it may be expected that the revenues increase directly with the wagon stock and inversely with

the length of haul. Hence, the railways would assign wagons to specific commodities in such a way that

$$SW = b_o (WS) L^{-1}$$

where

SW = supply of wagons.

WS = wagon stock.

b_o is a constant.

The following generalization may now be expected to adequately reflect the substitution possibilities alluded to earlier. For example, in the case of supply of wagons for loading coal, we expect

$$SW\ (coal) = B\ [\ (WS)\ L^{-1}\ ]^{\alpha}\ (IO)^{\beta}\ (IS)^{\gamma}$$

where SW (coal) = number of wagons used for loading coal.

IO = originating tonnage of iron ore.

IS = originating tonnage of iron and steel.

However, initial attempts to estimate this equation resulted in an unrealistically large value of α and we could not isolate the substitution effects. The simpler version was therefore utilized as an empirical approximation in the rest of the analysis. The estimated equations are presented in chapter 5.

CHAPTER 4

SOME OBSERVATIONS ON DATA

4.1 INTRODUCTION

The behavioural theory of the shipper's decisions developed in the previous chapter enables us to empirically examine the observed patterns of disequilibrium on the Indian Railways. However, notice that the microeconomic theory of the decisions regarding the quantum shipped and the length of haul has been developed to provide us a theoretical guideline for the empirical specification of the aggregate level models. We are neither interested in testing the behavioural theory with data at the level of the shippers nor do we really have access to such data. Moreover, even if such data were to be available it will not be possible to answer the questions posed in chapter 1.

Our primary interest is in examining macro-level freight movements on the entire Indian Railway system. For this purpose we obtained data for the time period 1960-1976. Besides the aggregate level data the requisite information was available for the following commodity level disaggregation: coal, iron ore, iron and steel, cement, fertilizers, food-grains, POL products and manufactured items.[1]

1. Details regarding the data are presented in the appendix to this chapter.

In the rest of the present chapter we endeavour to examine the following: (a) are the trends in available data in consonance with the theoretical hypothesis on a preliminary examination?, and (b) what other macro-economic changes, if any, can we identify in order to complete the empirical specification of the system of equations and proceed with estimation?

4.2 PRELIMINARY OBSERVATIONS

Table 4 provides an aggregate picture of the trends in the quantum shipped and the length of haul between 1960-61 and 1975-76 for various commodity movements on the Indian Railways. The following salient points may be noted: (a) The major freight movements on railways relate to coal, foodgrains and iron ore. In recent days even the movement of manufactured items is occupying a major share of total shipments. (b) The quantum shipped has been increasing only marginally both in the aggregate as well as for most specific commodities in recent years. (c) The overall change in the average length of haul is not very substantial. However, commodities like iron ore, cement, foodgrains, fertilizers and manufactured items recorded a very significant increase in the average length of haul.

TABLE 4. COMMODITY MOVEMENTS BY INDIAN RAILWAYS

S.No.	Commodity	S[a]		PTF[b]		L[c]	
		1960-61	1975-76	1960-61	1975-76	1960-61	1975-76
1.	Coal	30.88	64.30	25.77	32.67	664	581
2.	Iron Ore	10.51	25.59	8.77	13.00	263	384
3.	Iron & Steel	7.59	10.76	6.33	5.46	697	1005
4.	Cement	6.54	11.59	5.45	5.88	372	743
5.	Foodgrains	12.65	16.18	10.55	8.22	760	956
6.	Fertilizers	NA	7.20	-	3.65	NA	859
7.	Manufactured Items	NA	33.24	-	16.88	NA	983
8.	P.O.L. Products	4.70	11.70	3.92	5.94	544	605
9.	Aggregate[d]	119.80	196.80	-	-	561	664

Note: a. S = originating tonnage (millions).

b. PTF = S as a percentage of total revenue-earning freight movements by Indian Railways.

c. L = average length of haul (kilometres)

d. revenue earning freight movements alone are considered.

NA = not available.

Source: Ministry of Railways - Annual Statistical Statements.

Commodity specific patterns will be examined further in the following section.

4.3 COMMODITY-SPECIFIC PATTERNS

1. COAL

The coal mines are located in a few regions like the Bengal- Bihar coal belt, Orissa, Madhya Pradesh and Andhra Pradesh. With rapid progress in industrialization there has been an increase in the demand for specific grades of coal in different and often geographically dispersed regions. However, selected grades of coal are available only in the Bengal-Bihar coalfields. This was one of the major sources of increased haulage even after significant progress has been made in opening up new coal mines in other parts of the country like Maharashtra. Also, major consumers- such as the railways, thermal power stations and steel plants - received their supplies from these coalfields. This factor also contributes to a significant explanation of the observed increases in the quantum of coal handled by the railways.

Both the opening up of outlying coal fields in Maharashtra, Madhya Pradesh, Orissa and Andhra Pradesh as well as the more economical location of the super thermal

power stations near the pitheads may result in some reduction in the length of haul as well as the quantum of shipments. There is however an apprehension that the oil crisis may bring about fuel substitution in favour of coal thereby causing an increased pressure on shipments of coal. Regional dispersal of the major users of coal can be expected to provide us an adequate indicator of these factors in relation to their demand for freight services.

2. IRON ORE

Production of iron ore is mainly concentrated in the states of Orissa, Bihar, Madhya Pradesh, Karnataka and the Union Territory of Goa. These centres provide about 83% of the total production in the country.

Iron ore movements are basically for two purposes: (a) production of iron and steel, and (b) exports.[2] In the case of the former there has been an appreciable stabilization of the length of haul. However, a significant percentage of the quantum shipped has been for exports. And with an increase in the congestion at the nearby ports there has been a necessity to press far - off ports into service.

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2. Kadekodi, G., Iron Ore Export - Its Relevance for India, Productivity, May 1979.

As a consequence the increases in the length of haul have been significant.

3. IRON AND STEEL

The major steel plants are located at Rourkela in Orissa, Durgapur in West Bengal, Bhilai in Madhya Pradesh, Bokaro and Jamshedpur in Bihar. Such choices have been a result of the proximity to iron ore as well as high grade coking coal.

However, being a basic product for most of the higher levels of industrial products and construction activity the demand dispersal is significant. As a result, finished steel is carried over long distances to consumption centres all over the country. Both the quantum and the length of haul increased appreciably.

4. CEMENT

The basic raw material for cement manufacture is limestone. Geographically, this basic raw material is concentrated in the southern regions and in the adjoining areas of Bihar, Orissa, and Madhya Pradesh. The materials being bulky and weight losing in the conversion process, they have a significant influence on the location of the industry. The existing cement plants are mainly confined

to the states of Bihar, Orissa, Madhya Pradesh, Tamilnadu, Andhra Pradesh, Gujarat and Rajasthan. However, being a universal intermediary in all construction activity, the demand for cement is widespread geographically. This is the main factor which accounts for the observed increase in the quantum and length of haul.

5. FERTILIZERS

A good deal of geographic concentration of production is evident in this case as well. Most of the fertilizer plants are situated in the south and the west. It is also necessary to note that the domestic production of fertilizers has been insufficient to meet the growing demands. As a result, there have been significant imports of fertilizers into the country. Most of the time these imports are received at ports which are far off from the main consumption centres.

In contrast to this the dispersal of consumption has been quite significant. Further, with the emergence of the new agricultural strategy (green revolution) which was introduced in the mid-sixties the use of fertilizers and the market for it has shown a sharp increase. However, despite the reasonably widespread use of fertilizers relative to production there have been only a few significant

areas where the effect of the green revolution has been felt with a significant intensity.

There is one peculiarity about the observed movements of fertilizers. The net originating tonnage of fertilizer shipments far exceeds the quantity produced plus imports. There is an apriori feeling that there have been significant criss-cross movements of fertilizers and the freight demand patterns may in fact be quite inefficient.

6. FOODGRAINS

We generally expect that agricultural production would be widely dispersed and would correspond to the consumption requirements of a given region very closely. However, until about the mid-sixties there have been food shortages. They had to be perforce covered by imports. Even after the advent of the green revolution the production increases have been substantial only in a few areas and for a relatively small number of major crops. There was, for instance, a significant increase in the production of wheat in the northern states. But the production of rice was not affected. The relative sluggishness of the supply of agricultural commodities continued even after the green

revolution.[3] This state of changes in the patterns of production necessitated movements of foodgrains over long distances - from surplus to deficit areas.

The procurement and distribution policies of the Government and the relatively dispersed location of the warehouses of the Food Corporation of India seem to have had the effect of reducing the length of haul as well as improving the movements of foodgrains. Nevertheless, the length of haul remained high.

Also, for a few years of the sample, there have been significant imports of foodgrains under the U.S.P.L. 480 scheme. The imported wheat, which originated in a few ports like Bombay, Kandla and Madras, had to be distributed all over the country. In this context the pattern of shipments are similar to those for fertilizers.

7. MANUFACTURED ITEMS

This category of freight movements consists mainly of finished goods and is heterogeneous by nature. While the originating tonnage has increased only marginally from 27

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3. Shah, C.H., Narayanamurthy, S.G. , Gopalakrishnan, T.R., B. Bhaskara Rao, India in Perspective, Vol.3 (New Delhi: Arnold-Heinemann, 1978).

million tonnes in 1964-65 to 33 million tonnes in 1975-76, the average length of haul has gone up from 794 Kms to 983 Kms within the same period.

With the development of roads and the trucking industry during the past two decades, the movements of these high valued items shifted to trucks, particularly over short distances. The railways seem to retain this high valued traffic only for long distance shipments.

8. P.O.L. PRODUCTS

Though both the production and domestic supply of P.O.L. products (including imports) increased significantly over time there is as yet a significant concentration of production centres. However, the distribution network is rather widely dispersed. This is mainly a result of the efficient storage and distribution system of the Indian Oil Corporation. The length of haul for movements by railways remained high even with these arrangements because the Indian Oil Corporation utilizes trucks as a complementary mode for shorter haulages.

As in the other cases we have been considering the demand dispersal far outstrips the available supply and as a consequence both the quantum shipped by the railways and

the length of haul remained high. It would therefore be expected that there would be an increase in the quantum shipped as well. However, this has not materialized partly because a good deal of short haul shipments have been transferred to the truck mode. To an extent, such a shift has been necessitated by the shortage of oil tanker wagons even while there is an increase of demand on the railways.

4.4 SUMMING UP

The foregoing exposition indicates that in the case of specific commodity groups there can be (a) influences on the supply in addition to those indicated by the aggregate production level, (b) variables which will have to be added to the simple demand function specification of our analytical framework, and (c) certain intermodal and policy influences which have a bearing on both the length of haul and the quantum shipped.

Intermodal choices can in fact be quite significant while studying the choice of S and L by railways. In particular, the reduction in the reliability of service, both in terms of increase in transit times and the non-availability of wagons, appears to have compelled many shippers to shift to the truck mode. We could not, however, capture the effects of intermodal substitution primarily

due to paucity of comparable data on a time series basis. The explanatory variables therefore refer to the characteristics of the railway mode alone.

However, within the restricted framework we have chosen, we made an attempt to incorporate all the changes in specification - warranted by practical considerations - prior to empirical estimation. They have been suitably accounted for in the rest of the study.

APPENDIX

THE DATA*

TABLE 5. COAL

Year	L	p	t	S	Q	I	Q'
1960-61	664	99.20	2.15	30.88	55.70	182.50	9.91
1961-62	644	100.00	2.33	33.74	55.23	201.80	10.79
1962-63	593	104.90	2.58	39.26	63.83	218.60	12.17
1963-64	571	112.20	2.80	41.87	66.33	236.70	11.99
1964-65	561	116.30	2.93	40.71	64.38	256.90	14.31
1965-66	571	121.80	2.97	46.43	70.30	280.70	15.11
1966-67	540	128.50	3.12	46.29	71.20	278.50	16.26
1967-68	589	147.90	3.18	47.64	71.95	276.30	17.11
1968-69	575	161.20	3.49	50.84	75.40	294.00	17.98
1969-70	585	166.00	3.71	53.00	80.00	314.80	18.13
1970-71	581	167.90	3.79	47.89	75.30	329.90	19.75
1971-72	605	170.90	3.98	48.73	76.30	339.60	21.42
1972-73	587	176.80	4.13	51.10	80.20	363.90	22.88
1973-74	562	190.20	4.19	47.27	81.80	369.90	26.12
1974-75	595	244.30	5.51	55.32	91.60	377.20	30.66
1975-76	581	309.80	6.53	64.30	102.70	394.90	31.75

* Refer to note at the end of the appendix for an explanation of variables in Tables 5 - 13.

TABLE 6. IRON ORE

Year	L	p	t	S	Q	EXP	I & S
1960-61	263	98.70	4.38	10.51	11.00	3.46	9.68
1961-62	260	100.00	4.43	11.90	13.00	3.38	9.00
1962-63	259	102.80	4.75	14.33	13.50	4.06	11.03
1963-64	249	72.00	5.16	15.00	14.80	10.48	12.03
1964-65	258	68.40	5.15	15.33	15.10	11.26	12.16
1965-66	280	67.30	4.93	17.70	18.10	13.65	12.65
1966-67	298	94.30	5.04	18.10	19.40	13.57	12.85
1967-68	312	105.20	5.26	18.70	19.10	15.63	12.34
1968-69	339	109.20	5.38	20.73	21.20	15.11	12.86
1969-70	337	112.20	5.79	20.60	21.30	21.18	13.19
1970-71	351	109.10	5.92	21.27	32.50	19.91	11.47
1971-72	340	104.20	4.83	21.98	34.70	20.59	11.59
1972-73	341	105.10	6.07	21.43	35.70	23.74	12.29
1973-74	307	109.40	7.08	20.13	35.70	22.29	12.26
1974-75	351	129.60	7.91	21.53	37.00	23.42	13.44
1975-76	384	186.00	8.57	25.59	42.20	25.34	16.97

TABLE 7. IRON & STEEL

Year	L	p	t	S	Q	C
1960-61	697	97.40	5.99	7.59	9.68	620.00
1961-62	773	100.00	5.98	8.13	9.00	627.00
1962-63	799	104.20	6.09	9.44	11.03	661.00
1963-64	793	107.50	6.38	10.55	12.03	727.00
1964-65	829	112.20	6.50	10.60	12.16	745.00
1965-66	852	119.80	6.81	10.08	12.65	760.00
1966-67	913	124.80	6.88	9.78	12.85	739.00
1967-68	968	136.90	6.76	9.08	12.34	811.00
1968-69	935	144.10	7.46	9.65	12.86	1047.00
1969-70	967	150.10	7.34	9.98	13.19	1082.00
1970-71	1015	162.10	7.64	9.27	11.47	1081.00
1971-72	1028	175.90	7.84	9.24	11.59	1058.00
1972-73	1004	200.60	8.08	10.20	12.29	1114.00
1973-74	1016	234.60	8.07	9.28	12.26	1010.00
1974-75	1069	286.00	9.74	9.82	13.44	1073.00
1975-76	1005	306.70	11.30	10.76	16.97	1160.00

TABLE 8. CEMENT

Year	L	p	t	S	Q
1960-61	372	91.30	4.72	6.54	8.00
1961-62	388	100.00	4.66	6.70	8.30
1962-63	400	103.50	4.76	6.85	8.90
1963-64	401	108.30	5.01	7.24	9.40
1964-65	431	110.70	5.06	7.65	9.80
1965-66	456	122.70	5.08	8.64	10.70
1966-67	468	135.40	5.39	8.89	11.10
1967-68	484	135.20	5.66	9.35	11.50
1968-69	527	136.90	5.64	9.39	12.20
1969-70	583	145.70	5.46	10.70	13.80
1970-71	633	151.80	5.61	11.02	14.40
1971-72	617	160.00	5.92	11.22	15.00
1972-73	641	166.20	6.02	10.52	15.60
1973-74	635	170.90	6.29	10.02	14.70
1974-75	663	224.50	7.60	9.18	14.70
1975-76	743	258.80	8.44	11.59	17.20

TABLE 9. FOODGRAINS

Year	L	p	t	S	Q	IMP	DC
1960-61	760	101.90	3.01	12.65	82.01	3.49	3.98
1961-62	804	100.00	3.01	12.23	82.70	3.63	4.37
1962-63	823	105.40	3.07	12.34	80.15	4.55	5.18
1963-64	813	115.20	3.21	14.20	80.64	6.26	8.67
1964-65	788	145.50	3.29	13.75	89.35	7.45	10.08
1965-66	816	154.30	3.40	14.37	72.34	10.34	14.09
1966-67	792	182.90	3.49	16.44	74.23	8.67	13.17
1967-68	853	228.40	3.39	14.70	95.05	5.69	10.22
1968-69	849	201.00	3.56	15.85	94.01	3.87	9.39
1969-70	887	208.20	3.60	15.10	99.50	3.63	8.84
1970-71	961	206.80	3.69	15.09	108.42	2.05	7.81
1971-72	1059	214.90	3.66	15.50	105.16	0.45	10.48
1972-73	1181	247.50	3.59	15.79	97.02	3.61	11.41
1973-74	1114	296.00	3.60	14.64	104.66	4.87	10.79
1974-75	1110	401.50	3.78	13.66	99.82	7.40	11.25
1975-76	956	358.20	5.51	16.18	121.03	6.48	9.17

TABLE 10. FERTILIZERS

Year	L	p	t	S	Q	IMP	AG
1965-66	752	97.10	4.12	2.50	0.34	0.41	130.20
1966-67	675	103.20	4.64	3.50	0.45	0.89	137.70
1967-68	775	124.00	4.56	4.40	0.56	1.48	168.50
1968-69	828	125.70	4.44	5.00	0.75	1.20	156.80
1969-70	809	132.90	4.67	4.70	0.95	0.88	177.70
1970-71	811	135.60	5.18	4.70	1.05	0.63	190.50
1971-72	832	135.60	5.53	5.20	1.23	0.99	189.80
1972-73	869	143.00	5.96	5.40	1.38	1.19	174.60
1973-74	753	151.40	6.29	5.30	1.38	1.24	193.40
1974-75	801	275.00	7.83	6.00	1.51	1.60	187.50
1975-76	859	281.10	8.48	7.20	1.85	1.55	215.50
1976-77	929	236.00	8.42	7.80	2.38	1.05	222.80
1977-78	991	240.30	8.74	8.20	2.67	1.52	232.50

TABLE 11. MANUFACTURED ITEMS

Year	L	p	t	S	Q^a	A	NA	$p_{P.C.L.}$
1964-65	794	109.00	5.96	26.40	189.40	7223.77	0.54	123.20
1965-66	804	118.10	6.01	28.70	210.60	6147.85	0.59	125.00
1966-67	809	127.50	6.19	29.03	225.80	6021.04	0.62	132.50
1967-68	841	131.10	6.22	27.86	230.30	7075.64	0.57	137.90
1968-69	856	134.40	6.51	28.33	245.50	7155.48	0.58	141.00
1969-70	881	143.50	6.41	30.35	257.60	7611.64	0.58	150.10
1970-71	907	154.90	6.65	30.22	265.10	8137.47	0.57	157.30
1971-72	913	167.10	6.90	30.83	271.70	7985.56	0.59	171.50
1972-73	950	176.70	7.04	30.74	278.30	7284.27	0.62	179.70
1973-74	929	205.60	7.16	28.51	284.80	7945.43	0.59	236.20
1974-75	984	254.50	8.49	29.02	303.00	8020.50	0.59	390.70
1975-76	983	252.90	9.36	33.24	340.90	8410.00	0.58	410.90

Note: a. Index of manufacturing activity.

TABLE 12. P.O.L. PRODUCTS

Year	L	p	t	S	Q	IMP	CV	D
1960-61	544	98.10	6.96	4.70	5.80	2.03	1.71	15.44
1961-62	607	100.00	6.85	5.00	6.20	2.48	1.85	16.22
1962-63	626	101.50	7.02	5.50	6.90	2.98	2.15	16.83
1963-64	601	123.30	7.31	6.10	8.00	2.90	2.24	15.74
1964-65	625	123.20	7.42	6.20	8.50	2.95	2.41	14.12
1965-66	598	125.00	7.71	7.50	9.40	2.88	2.58	16.73
1966-67	554	132.50	7.72	7.80	11.90	2.20	2.68	16.16
1967-68	515	137.90	8.33	8.30	13.80	0.95	2.84	15.78
1968-69	576	141.00	8.52	7.90	15.40	0.93	3.06	17.57
1969-70	564	150.10	8.59	8.80	16.60	1.05	3.18	17.89
1970-71	594	157.30	8.87	8.90	17.10	0.97	3.42	18.74
1971-72	593	171.50	8.77	10.10	18.60	1.93	3.63	18.01
1972-73	614	179.70	8.82	10.20	17.90	3.25	2.99	18.87
1973-74	638	236.20	8.72	10.00	19.50	3.97	3.27	18.86
1974-75	642	390.70	10.50	10.80	19.60	2.94	3.36	18.31
1975-76	605	410.90	12.20	11.70	21.00	2.18	3.41	18.30

TABLE 13. AGGREGATE

Year	L	p^a	t	S	Q^b
1960-61	561	100.11	3.87	119.80	160.39
1961-62	568	100.00	3.97	125.60	171.30
1962-63	563	101.69	4.12	139.40	181.18
1963-64	559	104.55	4.36	147.60	192.00
1964-65	549	111.77	4.49	148.80	202.35
1965-66	576	134.69	4.57	162.00	230.90
1966-67	578	135.95	4.71	164.00	206.93
1967-68	605	146.03	4.85	162.40	217.92
1968-69	613	144.56	5.08	170.80	228.32
1969-70	617	153.18	5.17	173.80	242.09
1970-71	648	160.07	5.43	167.90	255.04
1971-72	674	165.20	5.61	170.10	261.08
1972-73	678	173.42	5.74	175.30	264.02
1973-74	662	204.01	5.89	162.10	271.91
1974-75	683	250.87	7.16	173.60	274.00
1975-76	664	258.69	8.12	196.80	309.01

Note: a. The price index is a weighted price index of the mining, industrial and agricultural sectors.

b. The index of aggregate output was obtained by dividing the nominal value of output of the mining, industrial and agricultural sectors by the unit price index.

Note for Tables 5 - 13:

The variables in the Tables are as follows:

L = length of haul (kilometres).

p = wholesale price index per unit of output (base: 1961-62 = 100).

t = average rate per tonne-kilometre (paise).

S = originating tonnage (millions).

Q = production (million tonnes).

I = index of industrial production (base:1950-51=100).

Q' = production of coal in outlying fields (million tonnes).

EXP = quantum of exports (million tonnes).

I&S = iron and steel production (million tonnes).

C = index of construction activity (value added in Rs.crores at 1960-61 prices).

IMP = quantum of imports (million tonnes).

DC = quantity of cereals distributed through the public distribution system (million tonnes).

AG = index of agricultural production (base:1950-51=100).

A = value added from agriculture (Rs.crores) at constant prices (base: 1960-61).

NA = ratio of non-agricultural income to national income.

$p_{P.O.L.}$ = wholesale price index of P.O.L.products (base: 1961-62 = 100).

CV = number of commercial vehicles on the highways (lakhs).

D = index of production concentration.

The index D was computed in the following manner:

D = $\sum_i |Q_i - \bar{Q}| / \bar{Q}$, where Q_i is value added by manufacture in state i, $\bar{Q}$ is the average per state, and the summation is over all the states of India.

APPENDIX (Contd.)

SOURCES OF DATA

(1) Ministry of Railways - Annual Statistical Statements and Annual Reports and Accounts.

(2) Central Statistical Organisation - Statistical Abstracts, Monthly Abstracts, National Income Statistics, Basic Statistics relating to the Indian Economy.

(3) Indian Bureau of Mines - Mineral Statistics of India and Indian Minerals Yearbook.

(4) Ministry of Agriculture and Irrigation - Food Statistics.

(5) Government of India - Economic Survey 1978-79.

(6) Rail Tariff Enquiry Committee - The Railways in the Indian Economy and Perspective for the Future.

(7) Economic and Scientific Research Foundation- Wholesale Price Statistics: India 1947- 1978, Vols. 1 and 2, October 1978.

CHAPTER 5

EMPIRICAL FINDINGS

5.1 INTRODUCTION

The model, as respecified in the previous chapter, has been estimated for each of the commodity groups for which data was available. The results are tabulated in Tables 14 and 15 given at the end of the chapter. The salient features of the estimated equations[1] will be considered in detail in what follows.

5.2 LENGTH OF HAUL EQUATION

Considering the sensitivity of the choice of length of haul to variations in the price of the commodity we observed three distinct patterns: (a) It is highly significant in the case of cement, iron ore and coal. In the first two cases the explanation is in consonance with the theory to the extent that there is a greater dispersal of markets and dispatches than those of production centres. Even in the case of coal, certain special grades of coal are available

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1. Rakowski (1976) found linear fits to be better. Almost all other studies found log-linear relations to be preferable. Though the differences were somewhat marginal we also found log-linear fits to be superior.

only in isolated locations though the demand is more widely dispersed. The reverse causation, viz., that the price differentials may themselves be a consequence of this could not be adequately tested. (b) Even in the case of iron and steel and P.O.L. products we observe sensitivity of the length of haul to output prices. However, this occurs at a lower level of significance primarily because there is systematic price control for these products. (c) The lowest price sensitivity is exhibited by the commodity groups foodgrains and manufactured items. In both these cases the markets are very nearly competitive due to the greater spread of production centres and smaller economical size of production units. In the case of foodgrains we even have a public distribution system which makes a deliberate attempt to stabilize prices of foodgrains. (d) In the case of fertilizers we have a freight equalization scheme in operation whereby the delivered price at all locations is sought to be equalized. Hence, it is not surprising that the price variable is not statistically significant though of the correct sign.

The length of haul is also generally sensitive to the freight rates. (a) The elasticities are the highest for iron and steel and P.O.L. products. This result is expected since these are bulky products and transport costs are

relatively a high percentage of total costs. (b) The elasticities with respect to transport rate are not equally as high in the case of iron ore, cement, foodgrains and coal partly because the demand for these commodities is relatively price inelastic and the shipper passes on increases in transport costs to the consumer in the form of increases in prices. (c) The transport costs are a relatively small fraction of total costs in the case of fertilizers and manufactured items. As such the lowest elasticities are recorded for these two commodity groups. (d) In the case of coal, iron ore and P.O.L. products the freight movements are unidirectional. As such a considerable movement of empty wagons is observed. We expect the shippers to perceive the increased opportunity cost even if it is not reflected in the freight rates actually charged. It may therefore be expected that the length of haul would be much more sensitive to the corrected t variable, as indicated in footnote b of Table 14. However, the adjusted t variable fared well only in the case of coal. For the other two cases we did not report the results because they are at best marginal. Even so, the estimated equations did not fare better than they have only because the adjustment was inadequate. Further work in this direction is warranted as and when more reliable data can be compiled on the social cost of

empty wagon movements.

Length of haul is almost always sensitive to the quantity of the commodity produced. (a) The highest positive coefficient is obtained in the case of cement. This merely reinforces our theoretical argument that the market remains highly monopolistic despite (or may be because of) all controls on price and quantity movements[2]. (b) Fertilizers, iron and steel and manufactured items have the next highest values of elasticity. Once again this result is in consonance with theory. (c) The elasticity of the length of haul with respect to output is negative in the case of coal and P.O.L. products. Part of the reason is the opening up of new coal mines and commissioning of new refineries reducing the necessity for long haulages. Secondly, especially in the case of coal, there are diseconomies of scale in mining operations which may account for the uneconomical nature of long hauls. However, in the case of coal the elasticity is numerically too large and may not be maintained in the future.

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2. This is one commodity which has been in acute short supply all along. The government sought to ration the available quantities through price control and also restricting movements across state boundaries. The present result shows the failure of the controls since the market forces are so potent that even a penalty system does not deter the shipper from violating controls.

While considering the effects of supply dispersal on the length of haul we also note the following: (a) The public distribution network for foodgrains is so widely developed that there is a warehouse of the Food Corporation of India in every district. This does appear to reduce the length of haul though as yet the effect is almost negligibly small. Part of the problem is the lack of a clear policy of releases during normal times. (b) Much of the foodgrains shortage, whenever it occurs, appears to primarily affect the large cities. Imports are generally received at these centres and cater to the deficit. Hence, the length of haul tends to get shorter with an increase in imports. (c) The case of imports of fertilizer is also similar because the ports are closer to the green revolution belt and the other highly developed agricultural states. (d) We already noted that in the case of P.O.L. products production is not widely dispersed though there has been some movement in that direction. But the Indian Oil Corporation and other distributors of P.O.L. products have an efficient localized storage system which effectively disperses regional availability (i.e., the index D is small and decreasing relative to the growth of demand). This feature accounts for the large reduction of the length of haul as the volume of production increases.

The effects of market demand dispersal on the length of haul may now be examined further. (a) In the case of iron ore a major share of movements is accounted for by the exports. They cause the length of haul to increase both due to the location of ports and the congestion in the nearby ports. (b) Construction activity and its observed widespread dispersal account for the demand patterns of cement and iron and steel. The estimated results indicate that the demand dispersal is relatively on the increase. (c) As expected, an increase in the commercial vehicles is the major demand factor in the case of P. O. L. products.

5.3 QUANTUM SHIPPED EQUATION

An examination of the estimated equations for the quantum shipped suggests that the effect of product prices is rarely significant[3]. This is one of our most important results. The length of haul is sensitive to commodity price variations but the quantum shipped is not. This can be explained within the theoretical framework in the following manner. Consider a given quantum of S. An increase in the length of haul may bring about sufficient price increases to make it profitable to go further and explore markets even

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3. Oum (1979) found these effects to be almost always significant.

in the face of increases in transport costs. However, for a given L, an increase in S may neutralize the advantage of an increase in price or even result in a loss of revenue depending on the nature of the market demand curve. Hence, there is no apriori necessity for S to be price sensitive just because L is.

The quantum shipped is not sensitive to the freight rates either[4]. It indicates a highly monopolistic market structure in which production is geared entirely to expected market demand. However the bulky products - cement, fertilizers, and iron and steel - exhibit the largest elasticities[5].

The quantum shipped is significantly influenced by the volume of production[6]. The elasticity exceeds unity in

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4. This result is similar to the observation of Oum (1979) and Hariton et. al (1976b).

5. The adjusted transport rate did not alter the results in any appreciable manner. Our observations regarding the length of haul equation are valid here as well.

6. The results of Hariton et.al (1976b) and Rao (1978a) are similar. Both these studies found close to unitary elasticity; the former for some commodity groups and the latter for all the commodities he studied. Hariton et.al (1976b) found the elasticities to be close to 0.33 for those commodities where the elasticity is not unitary. The smaller elasticity obtains for goods that are mainly consumed locally and unitary elasticity is observed when the commodities are mostly exported. This pattern is indicated by our results as well.

the case of cement and fertilizers. Primarily, these estimates can be explained as follows: the shipments from production centres reach warehouses in the first stage and are distributed to market centres from these warehouses. The reported originating tonnage is not merely movement from production centres but includes movements originating from warehouses as well. In a similar fashion, the movements to and out of regional coal dumps also caused a high elasticity. However, the contrasting small elasticity for foodgrains can be explained as in Hariton et.al (1976b) by observing that the quantum shipped is inelastic due to inflexible long-term contracts.

An increase in the length of haul has a negative effect on the quantum of coal shipped[7]. This seems to indicate the preponderance of the supply bottleneck. For, it has been observed that there have been very significant delays in obtaining the requisite wagons for shipment and receiving shipments after wagons are loaded as the movements of coal increased.

Exports are a major constituent of iron ore movements. Increases in iron and steel production constitutes the other

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7. This result is in contrast to the findings of Rakowski (1976) and our own initial maintained hypothesis.

major source of demand. It may also be noted that there is a significant increase in S but not in L as the production of iron and steel increases primarily due to the production being largely confined to the vicinity of the mines.

In the case of manufactured items the increase in non-agricultural incomes has a much more significant impact on demand though even agricultural incomes contribute to it substantially. The other pertinent observation is that the substitution away from trucks to railways is already quite significant as indicated by the price of P.O.L. products in the equation.

Increases in the number of commercial vehicles on the road is the major demand factor affecting the shipments of P.O.L. products. Observe that the efficient distribution system based on regionalized warehouses does not reduce the quantum shipped though, as we have already noted, it helps in reducing the length of haul[8].

On the whole, one of the most important findings is that a greater regional dispersal of supply availability helps reduce length of haul whether it is achieved through

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8. Our results contrast with those of Hariton et.al (1976b) who found that consumption at the destination is much less significant compared to production at the origin.

imports or through a regional network of warehouses. However, this does not decrease the quantum shipped. Quite the contrary the empirical evidence indicates that there will be an increase. The significantly large cross hauls of fertilizers and cement which are empirically observed corroborate this viewpoint.

5.4 CONCLUSION ON THE S AND L EQUATIONS

Our study of disaggregated behavioural models of length of haul and freight movements leads us to the following major conclusions.

(1) The length of haul, and not the quantum shipped, is sensitive to variations in transport rates and increases in demand as reflected by product prices. This trend is much more prominent in the case of bulk movements than others.

(2) Both growth and regional patterns of availability and demand have a major role in determining both the length of haul and the quantum shipped. The demand factors predominate in both decision processes[9].

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9. In the case of iron and steel and cement the shortfall in production has been so severe relative to demand that none of the factors affecting the latter appear in the S equation. But the demand pressure has been such that domestic supply is augmented by imports. Hence, to an extent the distinction gets blurred.

(3) Note that the expected speculative movements of freight, due to increases in length of haul, have not materialized. The observed congestion in the system is purely in terms of delays and movement of large volumes of freight.

(4) It has been observed that the length of haul could be reduced (though in varying degrees depending on the commodity in question) in almost all cases where supply could be dispersed geographically in consonance with the pattern of demand. The quantum shipped invariably increases with all such arrangements. This may, however, be a consequence of the same tonnage moving from a production centre to a warehouse and in return to a market and being counted separately as originating tonnage on each of these occasions.

(5) It is essential to examine the impact of shorter hauls on wagon requirements rather than depend on tonnage alone. Further, the supply of wagons may improve with shorter hauls and lower turnaround times. This may facilitate provision of wagons even if the requirements increase somewhat. We could not however assess this from the available information.

(6) More importantly, it should be recognized by the policy maker that the piecemeal decision of increasing freight rates is not sufficient to induce regional spread of production and warehouse facilities. The additional costs of warehouse facilities will have to be evaluated against the transport cost reductions.

5.5 VALIDATION OF RW AND SW SPECIFICATION

Recall that the equations for the requirement of wagons and the supply of wagons have been postulated to be

$RW = a_0 (S) (L)$, and

$SW = b_0 (WS) (L^{-1})$

Such a specification embodies a hypothesis about the behaviour of shippers and the management of the railways. In particular, both the equations embody the assumption that the turnaround time of wagons is primarily an inverse function of the average length of haul. It is however quite clear that the former depends on the more complex process of scheduling wagons and movement on the railway network. Hence, there is a need to ascertain the extent to which the approximate theoretical specification reproduces observed patterns of behaviour.

From an empirical viewpoint we encounter a further problem. For, the only observations available to us are the actual wagon loadings. The theoretically defined <u>ex ante</u> magnitudes RW and SW are not available. It is also clear from the outset that the system is not in equilibrium at any point of time. We therefore cannot assume that RW = SW = actual wagon loadings observed.

In order to rescue the system from the estimation problem we have two alternatives: (a) to use one of the many disequilibrium methods of estimation which are available, or (b) to consider more closely the empirical approximation which would be adequate for the purpose at hand. We rejected the former approach mainly because there is no adequate understanding of the disequilibrium behaviour quite in contrast to the market disequilibrium estimation of the other studies.

It was then noted that by the inherent logic of the system under consideration there are forces, internal to the decision making process of both the shippers and the railway management, which generate disequilibrating momentum even if we start in a state of equilibrium. And, for all practical purposes, our primary endeavour is to understand this disequilibrating mechanism and find ways

of remedying it if possible. For, the actual excess demand which manifests itself in the system is greater than that which will be predicted by assuming that RW = SW = actual wagon loadings. The actual, and more complex, problem cannot be adequately analyzed if we do not find the simpler problem manageable.

Hence, it was decided that the two equations will be estimated under the assumption that RW = SW = actual wagon loadings. The two equations under discussion are identifiable under this assumption.

Since the theoretical analysis does not justify using specification like

$$RW = a_o\, S^{\alpha}\, L^{\beta}, \text{ where } \alpha\ ,\ \beta \neq 1$$

we did not use these general functional forms. Even testing a hypothesis $\alpha = 1$ and $\beta = 1$ does not appear warranted due to lack of a theoretical motivation for the alternative. Hence, simple classical least squares estimates of a_o and b_o are obtained without any other constants in the regressions.

The resulting estimates are presented in Tables 16 and 17 given later. On the whole, we find that the approximations are usable though the R^2 values appear to be exaggerated.

This completes our presentation of the empirical estimation and validation of the models. We turn to the implications of these results in the next chapter.

TABLE 14. ESTIMATED EQUATIONS FOR LENGTH OF HAUL[a]

S.No.	Commodity	p	t	Q	EXP	G
1	2	3	4	5	6	7
1.	Coal[b]	0.57 (3.59)	-0.29 (1.28)	-0.72 (2.75)	-	-
2.	Iron Ore	0.42 (7.45)	-0.28 (2.88)	-	0.17 (7.90)	-
3.	Iron and Steel	0.37 (2.20)	-0.70 (1.81)	0.19 (1.13)	-	0.37 (3.27)
4.	Cement[c]	0.45 (1.77)	-0.35 (1.12)	0.49 (2.65)	-	0.19 (1.57)
5.	Foodgrains[c,d]	0.29 (2.97)	-0.29 (1.46)	-	-	-
6.	Fertilizers[e]	0.10 (0.52)	-0.22 (0.77)	0.18 (2.43)	-	-
7.	Manufactured Items[f]	0.25 (2.82)	-0.11 (0.65)	0.12 (2.02)	-	-
8.	P.O.L.Products[g]	0.30 (3.51)	-0.63 (2.24)	-0.29 (2.23)	-	-
9.	Aggregate[c,h,i]	0.17 (1.30)	-0.04 (0.21)	0.10 (0.56)	-	-

(contd..)

TABLE 14. (Contd.)

IMP	DC	CV	D	$\bar{R}^2$	DW
8	9	10	11	12	13
-	-	-	-	0.63	2.51
-	-	-	-	0.94	2.79
-	-	-	-	0.85	1.63
-	-	-	-	0.98	2.45
-0.04 (1.27)	-0.02 (0.19)	-	-	0.39	1.36
-0.04 (0.65)	-	-	-	0.59	1.62
-	-	-	-	0.93	1.96
-	-	0.41 (1.95)	0.41 (1.97)	0.53	2.24
-	-	-	-	0.46	1.16

Notes for Table 14:

a. The variables in the equations are as follows:

p = wholesale price index per unit of output.

t = average rate per tonne - kilometre.

Q = production.

EXP = quantum of exports.

C = index of construction activity (value added at 1960-61 prices).

IMP = quantum of imports.

DC = quantity of cereals distributed through the public distribution system.

CV = number of commercial vehicles on the highways.

D = index of production concentration.

The index D, of regional production concentration was computed in the following manner.

$D = \sum_i | Q_i - \bar{Q} | / \bar{Q}$, where Q_i is the value added by manufacture in state i, $\bar{Q}$ is the average per state, and the summation is over all the states of India.

All the equations are estimated in log-linear form.

We are not presenting the constants in the equations.

Further, a blank in any one column indicates that the

variable was not included in the final equation. The numbers in brackets are the t-values of the corresponding coefficients. $\bar{R}^2$ is the adjusted coefficient of determination and DW refers to Durbin-Watson Statistic.

b. The t variable is adjusted. The actual transport rate, which is generally a subsidized rate, was quite insignificant though of the correct sign. We felt that the empty wagon movements create an increase in the costs of operation for the shipper as well. We therefore multiplied the actual rate by the ratio of total wagon Kms to the loaded wagon Kms and made an index to get the adjusted t. It was postulated that the shipper is more likely to respond to this adjusted transport rate. We observe in passing that at least one observer of the Indian scene, namely Khosal (cf., Khosal, R.K., Economics of Broad Guage Railways: Indian Experience, Indian Economic Journal, January 1971, pp. 347-370) observed that the railway freight tariff is in excess of marginal cost. But no other study ever found any such evidence.

c. This equation has been obtained after correcting for autocorrelation of residuals.

d. The first order autocorrelation correction was insufficient. The heterogeneity of the aggregate comprising "foodgrains" did not really give us any clue as to which missing variable is the major reason for this. It may also be pointed out that the $\bar{R}^2$ dropped significantly after the autoregressive transformations. The original estimated equation was

$$\text{Log L} = \text{constant} + \underset{(3.70)}{0.36}\ \text{Log p}\ \underset{(1.35)}{-0.34}\ \text{Log t}$$

$$\underset{(2.13)}{-0.07}\ \text{Log IMP}\ \underset{(0.32)}{-0.03}\ \text{Log DC},\quad \bar{R}^2 = 0.70,$$

$$DW = 1.11$$

e. The estimation in this case is based on data from 1965-66 to 1977-78 unlike in the other commodity groups.

f. The data for this commodity group refers to the years 1964-65 to 1975-76 only.

g. In the case of the P.O.L. products the quantum of imports constitute a significant percentage of domestic supply. Hence in this case Q was taken to be the quantity domestically produced plus the quantum of imports.

h. The first order autocorrelation correction that we used was definitely insufficient in this case. Quite clearly a good many omitted variables account for this. The available data did not improve the results in many trials. The other aspect worth recording is that the $\bar{R}^2$ of the equation was very high if we do not correct for possible autocorrelation. The estimated equation was

$$\text{Log } L = \text{constant} + \underset{(1.29)}{0.21} \text{ Log } p \; - \underset{(0.51)}{0.11} \text{ Log } t$$

$$+ \underset{(1.15)}{0.18} \text{ Log } Q, \quad \bar{R}^2 = 0.80, \quad DW = 0.69$$

i. The index of aggregate output was obtained by dividing the nominal value of output of the mining, industrial and agricultural sectors by the unit price index.

TABLE 15. ESTIMATED EQUATIONS FOR QUANTUM SHIPPED[a]

S.No.	Commodity	p	t	Q	L	EXP	IS
1	2	3	4	5	6	7	8
1.	Coal	-	-0.23 (0.99)	1.43 (3.26)	-0.41 (1.35)	-	-
2.	Iron Ore	-	-0.11 (0.74)	-	0.69 (3.42)	0.19 (4.02)	0.35 (1.72)
3.	Iron and Steel[b,c]	-	-0.18 (1.49)	0.56 (3.70)	-	-	-
4.	Cement[b,d]	-	-0.27 (1.49)	1.38 (3.45)	-0.48 (1.05)	-	-
5.	Foodgrains	-	-	0.17 (1.35)	-	-	-
6.	Fertilizers[b,e,f]	0.15 (1.04)	-0.51 (0.28)	1.37 (1.81)	-	-	-
7.	Manufactured Items[g]	-1.13 (2.46)	-	0.32 (1.96)	-	-	-
8.	P.O.L. Products[h]	0.17 (1.01)	-0.06 (0.14)	0.34 (1.84)	-0.09 (0.25)	-	-
9.	Aggregate	-	-	0.88 (4.21)	-0.64 (1.89)	-	-

(contd...)

TABLE 15. (Contd.)

IMP	DC	$p_{P.O.L.}$	A	NA	CV	$\bar{R}^2$	DW
9	10	11	12	13	14	15	16
-	-	-	-	-	-	0.94	1.65
-	-	-	-	-	-	0.94	1.75
-	-	-	-	-	-	0.56	1.76
-	-	-	-	-	-	0.88	1.58
-0.02 (0.78)	0.19 (4.10)	-	-	-	-	0.61	2.21
0.55 (0.71)	-	-	-	-	-	0.59	2.48
-	-	0.53 (2.34)	0.91 (1.94)	2.56 (2.41)	-	0.74	2.98
-	-	-	-	-	0.33 (1.02)	0.96	1.80
-	-	-	-	-	-	0.87	1.53

Notes for Table 15:

a. All the estimated equations are in log-linear form. Constants in the estimated equations are not presented. A blank in any one column indicates that the variable was not included in the final equation. The numbers in brackets are t-values of corresponding coefficients. $\bar{R}^2$ is the adjusted coefficient of determination and DW is the Durbin-Watson Statistic. The following variables are in addition to those listed in Table 14.

I = index of industrial production.

IS = iron and steel production.

$P_{P.O.L.}$ = wholesale price index of P.O.L. products.

A = value added from agriculture.

NA = ratio of non-agricultural income to national income.

b. Adjusted for first order autocorrelation.

c. $\bar{R}^2$ reduced significantly as a result of the transformations. The original estimated equation was

$$\text{Log } S = \text{constant} \underset{(1.64)}{-0.22} \text{ Log } t \underset{(4.43)}{+ 0.74} \text{ Log } Q \ ,$$

$$\bar{R}^2 = 0.67 \ , \quad DW = 1.16$$

d. Even in this case $\bar{R}^2$ reduced after transformation. The original equation was

$$\text{Log } S = \text{constant} \underset{(1.82)}{-0.30} \text{ Log } t + \underset{(3.68)}{1.39} \text{ Log } Q \underset{(1.11)}{-0.51} \text{ Log } L \text{ ,}$$

$$\bar{R}^2 = 0.95 \text{ , } DW = 1.13$$

e. The $\bar{R}^2$ was much higher before the autoregressive transformation. The estimated equation was

$$\text{Log } S = \text{constant} + \underset{(0.87)}{0.18} \text{ Log } p \underset{(0.89)}{-0.28} \text{ Log } t + \underset{(5.38)}{0.44} \text{ Log } Q$$

$$+ \underset{(2.83)}{0.20} \text{ Log } IMP \text{ , } \bar{R}^2 = 0.96, \text{ } DW = 1.13$$

f. The estimation is based on data from 1965-66 to 1977-78.

g. The data for this commodity group refers to the years 1964-65 to 1975-76.

h. As in the case of the length of haul equation Q denotes available domestic supply including imports for this case.

TABLE 16. ESTIMATED EQUATIONS FOR REQUIREMENT OF WAGONS

S.No.	Commodity	SL^a	R^2
1.	Coal	2.76 (37.72)	0.98
2.	Iron Ore	5.37 (28.31)	0.98
3.	Iron & Steel	1.91 (61.79)	0.99
4.	Cement	3.09 (24.88)	0.97
5.	Foodgrains	1.88 (35.31)	0.98
6.	Fertilizers	2.30 (35.15)	0.99
7.	Manufactured Items	2.04 (49.93)	0.99
8.	P.O.L. Products	3.03 (46.16)	0.99
9.	Aggregate	3.00 (35.31)	0.98

Note: a. Figures in brackets are t-values.

TABLE 17. ESTIMATED EQUATIONS FOR SUPPLY OF WAGONS

S.No.	Commodity	$(WS)L^{-1}$[a]	R^2
1.	Coal	119.44 (24.41)	0.97
2.	Iron ore	34.44 (7.09)	0.77
3.	Iron & Steel	41.22 (21.24)	0.96
4.	Cement	21.21 (9.70)	0.86
5.	Foodgrains	61.11 (19.30)	0.96
6.	Fertilizers	18.56 (10.89)	0.92
7.	Manufactured Items	124.23 (25.75)	0.98
8.	P.O.L. Products	23.52 (13.70)	0.93
9.	Aggregate	491.95 (19.68)	0.96

Note: a. Figures in brackets are t-values.

CHAPTER 6

SOME RESULTS OF POLICY SIMULATION

6.1 PURPOSE OF THE SIMULATION EXERCISE

As stated at the outset one of the objectives of the present study is to assess the extent of excess demand for freight services that is likely to be generated by output growth in various sectors and to examine the extent to which the various policy options that are available can alleviate the problem.

The exercise is initiated by considering the effect of three rates of growth in output: low, average and high rates.[1,2] This is the major exogeneous change which is contributing to the wagon requirements.

The increase in wagon requirements can be reduced by suitable freight rate changes which affect S or L or both. Alternatively, a reduction in L together with an increase in the wagon stock can increase the supply of wagons thereby reducing the net excess demand for wagons. Essentially these are the policy options considered in the simulation exercise.

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1. We considered changes in the output for each of the commodities in the past five years and took the 3 rates.

2. In the case of iron ore, exports were considered instead of production.

In order to ascertain the relative efficiency of the policy instruments we considered the following alternatives sequentially: (a) Variation in the freight rates. The low, average and high rate change options have all been considered. (b) Increases in wagon stock. Here again the high rate of 2 per cent increase in wagon stock, which the railways have been planning for, though it has not been achieved so far has been considered as one of the options. (c) A combination of the above two alternatives has also been tried out in cases where neither of them is able to create a positive net excess supply if operated in isolation. (d) We also examined the effect of dispersal or warehousing policy as an aid to reducing the net excess demand on the rail freight network.

6.2 METHODOLOGICAL DETAILS

In chapter 3 we developed a microeconomic theory of shippers decisions with respect to the quantum shipped and the length of haul. These, in turn, were utilized to develop equations reflecting the requirement and supply of wagons for each commodity group.

The resulting system of four equations, in its estimated empirical form, is as follows:

(a) the length of haul equation

$$L = (\text{constant})\ p^{a_1}\ t^{a_2}\ Q^{a_3}$$

(b) the quantum shipped equation

$$S = (\text{constant})\ p^{b_1}\ t^{b_2}\ Q^{b_3}\ L^{b_4}$$

(c) the requirement of wagons equation

$$RW = (\text{constant})\ (S)\ (L)$$

(d) the supply of wagons equation

$$SW = (\text{constant})\ (WS)\ (L)^{-1}$$

Based on the above system of equations, percentage changes in each of the variables under consideration can be represented as follows:

$$\frac{dL}{L} = a_1 \frac{dp}{p} + a_2 \frac{dt}{t} + a_3 \frac{dQ}{Q}$$

$$\frac{dS}{S} = b_1 \frac{dp}{p} + b_2 \frac{dt}{t} + b_3 \frac{dQ}{Q} + b_4 \frac{dL}{L}$$

$$\frac{dRW}{RW} = \frac{dS}{S} + \frac{dL}{L}$$

$$\frac{dSW}{SW} = \frac{d(WS)}{WS} - \frac{dL}{L}$$

CASE 1:

Taking $\frac{dQ}{Q} > 0$ and $\frac{dp}{p}$, $\frac{dt}{t}$, $\frac{dWS}{WS} = 0$,

We have

$$\frac{dL}{L} = a_3 \frac{dQ}{Q}$$

$$\frac{dS}{S} = b_3 \frac{dQ}{Q} + b_4 \frac{dL}{L}$$

$$= b_3 \frac{dQ}{Q} + b_4 \left(a_3 \frac{dQ}{Q} \right)$$

$$= b_3 \frac{dQ}{Q} + a_3 b_4 \frac{dQ}{Q}$$

$$= (b_3 + a_3 b_4) \frac{dQ}{Q}$$

$$\frac{dRW}{RW} = (b_3 + a_3 b_4) \frac{dQ}{Q} + a_3 \frac{dQ}{Q}$$

$$= (b_3 + a_3 b_4 + a_3) \frac{dQ}{Q}$$

$$\frac{dSW}{SW} = - a_3 \frac{dQ}{Q}$$

Net Excess Supply of Wagons can therefore be represented by

$$NES = \frac{dSW}{SW} - \frac{dRW}{RW}$$

$$= - a_3 \frac{dQ}{Q} - (b_3 + a_3 b_4 + a_3) \frac{dQ}{Q}$$

$$= - (b_3 + a_3 b_4 + 2 a_3) \frac{dQ}{Q}$$

CASE 2 :

We then consider a case where $\frac{dQ}{Q} > 0$, $\frac{dt}{t} > 0$ and $\frac{dp}{p}$, $\frac{dWS}{WS} = 0$

Under these conditions it follows that

$$\frac{dL}{L} = a_2 \frac{dt}{t} + a_3 \frac{dQ}{Q}$$

$$\frac{dS}{S} = b_2 \frac{dt}{t} + b_3 \frac{dQ}{Q} + b_4 \frac{dL}{L}$$

$$= b_2 \frac{dt}{t} + b_3 \frac{dQ}{Q} + b_4 (a_2 \frac{dt}{t} + a_3 \frac{dQ}{Q})$$

$$= (b_2 + a_2 b_4) \frac{dt}{t} + (b_3 + a_3 b_4) \frac{dQ}{Q}$$

$$\frac{dRW}{RW} = (b_2 + a_2 b_4) \frac{dt}{t} + (b_3 + a_3 b_4) \frac{dQ}{Q} + (a_2 \frac{dt}{t} + a_3 \frac{dQ}{Q})$$

$$= (b_2 + a_2 + a_2 b_4) \frac{dt}{t} + (b_3 + a_3 + a_3 b_4) \frac{dQ}{Q}$$

and

$$\frac{dSW}{SW} = - (a_2 \frac{dt}{t} + a_3 \frac{dQ}{Q})$$

Therefore, we have

$$NES = - (b_2 + 2a_2 + a_2 b_4) \frac{dt}{t} - (b_3 + 2a_3 + a_3 b_4) \frac{dQ}{Q}$$

CASE 3:

Assume next that $\frac{dQ}{Q}$, $\frac{dWS}{WS} > 0$

and $\frac{dp}{p}$, $\frac{dt}{t} = 0$

For this case it may be verified that

$$NES = \frac{dWS}{WS} - (b_3 + 2a_3 + a_3 b_4) \frac{dQ}{Q}$$

CASE 4:

Let $\frac{dQ}{Q} > 0$, $\frac{dt}{t} > 0$, $\frac{dWS}{WS} > 0$ and $\frac{dp}{p} = 0$

be postulated instead. We then obtain

$$NES = \frac{dWS}{WS} - (b_2 + 2a_2 + a_2 b_4) \frac{dt}{t} - (b_3 + 2a_3 + a_3 b_4) \frac{dQ}{Q}$$

6.3 RESULTS OF SIMULATION

A simulation exercise was undertaken for the four cases considered above with alternative rates of growth postulated for each of the exogeneous and policy variables. The pertinent results are summarized in Table 18 - 26 given at the end of the chapter and the following paragraphs.

To begin with, we note that the effect of a change in output alone is to generate an excess demand on the system. This is the case for all commodity groups with the lone exception of P.O.L. Products. In the case of the latter group, we notice that there is a high negative coefficient on the output variable Q in the length of haul equation. This is the primary reason for the observed outcome. The production dispersal which occurred in recent years has been the major factor which accounts for the negative coefficient of Q. However, it appears unlikely that this trend will continue in the future as well. Hence, in one of the simulations we set this coefficient at a value zero. It was then observed that net excess demand becomes a distinct possibility even in the case of P.O.L. Products.

Consider the effects of changes in the freight rate 't'. In the case of coal, only the highest rate of increase

of 25 per cent in 't' enables the system to generate a net excess supply for all rates of output growth. For a lower rate of 1 per cent and an average rate of 7 per cent growth in output even smaller changes of 3 per cent and 15 per cent in 't' make the net excess supply positive. The same pattern emerges for iron ore, foodgrains and P.O.L. products as well. But for commodity groups such as cement, fertilizers and manufactured items, the demand pressure is acute except for the lowest rates of output growth. Therefore, for these commodity groups the demand pressure dominates the effects of increases in freight rates.

The next part of the exercise considered changes in wagon stock in addition to changes in output while the freight rate 't' was retained at the existing level. The policy of increasing the wagon stock results in net excess supply of wagons being positive only for low rates of growth of output in the case of coal, iron and steel, foodgrains and P.O.L. products. As for cement, fertilizers and manufactured items, this policy is totally ineffective. If the freight rate policy was considered insufficient to generate a net excess supply for these commodity groups, the wagon stock policy appears to be far more inferior. On the whole, though the freight rate policy may appear to be marginally superior, the problem of acute pressure on the wagon supply

seems much more complex and cannot be solved by mere changes in freight rates or wagon stock.

When both policy measures are under operation simultaneously with changes in Q, the results are at best marginal[3]. For cement and manufactured items, there was some improvement with a freight rate increase of 15 per cent resulting in net excess supply for low and average rates of growth in output and for all rates of changes in wagon stock. For the highest rate of growth of output, the problem remains acute. As regards fertilizers, a freight rate increase of 25 per cent reduces the pressure only for a low output growth rate. At the aggregate level, there is hardly any improvement even when both policies are in operation. We present a few major results in Figures 7 and 8 at the end of the chapter.

The effect of the dispersal variable is rarely significant. In the case of foodgrains, where the public distribution of cereals (DC) reflects a certain dispersal pattern, we find that the output effect on the volume shipped overtakes the dispersal effect on the length of haul.

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3. Simultaneous changes in 't' and 'WS' are considered only for cement, fertilizers, manufactured items and aggregates. These were the commodity groups which were unaffected by either of the policies taken in isolation.

Consequently, additional requirement of wagons is much more than the corresponding augmentation in the wagon supply due to the shortening of the length of haul. The reason for this result may be the fact that we have an accounting problem in the specification of the originating tonnage. For, while the specification makes the wagon requirements increase, we could not identify any corresponding increase in supply which may well be possible due to better scheduling of movements over shorter distances.

In the case of P.O.L. products the dispersal variable appears in the length of haul equation alone and affects the quantum shipped only indirectly. With an increase in dispersal to the extent of 2 per cent the pressure on the requirement of wagons decreases through the negative effect of the length of haul on the quantum shipped. It is therefore evident that only the highest rate of dispersal provides an improvement in the net excess supply of wagons.

6.4 FURTHER OBSERVATIONS

From the foregoing analysis it appears that the problem of providing an adequate wagon supply is most severe in the case of fertilizers. The two policy measures considered in the present study do not appear to generate the requisite quantum of freight services. However, the

demand for fertilizers is seasonal and coincides with the peak time for movement of foodgrains as well. A system of warehouses may therefore enable the railways to move fertilizer at some suitable slack time and lessen the burden on the wagon capacity during the busy season.

In the case of movements of coal, our results indicate the sufficiency of the policy measures considered above. But the substitution away from oil towards coal, as a result of the oil crisis, is likely to increase coal movements in a significant manner. This is a potential problem. The proposal, which is being mooted by the Ministry of Energy[4], for setting up regional coal dumps may go a long way in mitigating the problem of excess burden on the existing wagon stock.

The case of cement is somewhat different. At the present stage we find that the quantum shipped as well as the length of haul are very large and are not adequately amenable to the policy variations considered above. The warehousing policy may appear to deserve being considered in this case as well. However, the quantity produced is

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4. The Union Ministry of Energy is to set up initially coal dumps in the states of Uttar Pradesh, West Bengal, Haryana, Punjab, Tamilnadu and Himachal Pradesh. See, The Economic Times, September 11, 1980.

too low to satisfy demand as it arises at a point of time and there is hardly any possibility of developing adequate storage. Basically, therefore, the long haul movements which are being observed of late are caused by extreme production shortages. Only by improving this can we check the excess demand. Warehousing concepts may then provide a useful complement.

It is thus clear that warehousing concepts and consequent reductions in length of haul can be advantageously utilized to augment the efficacy of the transport rate and wagon stock policies.

RESULTS OF SIMULATION

TABLE 18. EFFECT OF POLICY VARIABLES ON SUPPLY OF WAGONS FOR COAL MOVEMENTS

The estimated equations are:

(1) $L = (\text{constant})\ P^{0.57}\ t^{-0.29}\ Q^{-0.72}$

(2) $S = (\text{constant})\ t^{-0.23}\ Q^{1.43}\ L^{-0.41}$

Percentage changes in Q considered are:

(a) 1.32, , (b) 7.27 , (c) 12.11

dPV		dL	dS	dRW	dSW	dNES
1		2	3	4	5	6
t = 0, WS = 0	(a)	-0.95	2.26	1.31	0.95	-0.36
	(b)	-5.23	12.53	7.30	5.23	-2.08
	(c)	-8.71	20.88	12.17	8.71	-3.46
t = 3.00, WS = 0	(a)	-1.82	1.93	0.11	1.82	1.71
	(b)	-6.10	12.20	6.10	6.10	0.00
	(c)	-9.58	20.54	10.96	9.58	-1.38
t =15.00, WS = 0	(a)	-5.30	0.60	- 4.70	5.30	10.00
	(b)	-9.58	10.86	1.28	9.58	8.30
	(c)	-13.06	19.21	6.15	13.06	6.91

contd...

TABLE 18. (Contd.)

1		2	3	4	5	6
t =25.00	(a)	-8.20	-0.51	-8.71	8.20	16.91
WS = 0	(b)	-12.48	9.76	-2.72	12.48	15.20
	(c)	-15.96	18.11	2.15	15.96	13.81
t = 0	(a)	-0.95	2.26	1.31	1.46	0.15
WS =0.51	(b)	-5.23	12.53	7.30	5.74	-1.56
	(c)	-8.71	20.88	12.17	9.22	-2.95
t = 0	(a)	-0.95	2.26	1.31	2.04	0.73
WS = 1.09	(b)	-5.23	12.53	7.30	6.32	-0.98
	(c)	-8.71	20.88	12.17	9.80	-2.37
t = 0	(a)	-0.95	2.26	1.31	2.95	1.64
WS = 2.00	(b)	-5.23	12.53	7.30	7.23	-0.07
	(c)	-8.71	20.88	12.17	10.71	-1.46

Note: dPV = percentage changes in policy variables, the freight rate 't' and wagon stock 'WS'.

dL = percentage changes in the length of haul 'L'.

dS = percentage changes in the quantum shipped 'S'.

dRW = percentage changes in the requirement of wagons 'RW'.

dSW = percentage changes in the supply of wagons 'SW'.

dNES = percentage changes in net excess supply of wagons 'NES'.

TABLE 19. EFFECT OF POLICY VARIABLES ON SUPPLY OF WAGONS FOR IRON ORE MOVEMENTS

The estimated equations are:

$$(1)\ L = (\text{constant})\ P^{0.42}\ t^{-0.28}\ EXP^{0.17}$$

$$(2)\ S = (\text{constant})\ t^{-0.11}\ L^{0.69}\ EXP^{0.19}\ IS^{0.35}$$

Percentage changes in Exports* considered are:

(a) 3.41 , (b) 5.46 , (c) 15.29

dPV		dL	dS	dRW	dSW	dNES
1		2	3	4	5	6
t = 0, WS = 0	(a)	0.57	1.03	1.60	-0.57	-2.17
	(b)	0.92	1.66	2.58	-0.92	-3.50
	(c)	2.59	4.68	7.27	-2.59	-9.86
t = 8.95, WS = 0	(a)	-1.93	-1.68	-3.61	1.93	5.54
	(b)	-1.58	-1.05	-2.63	1.58	4.21
	(c)	0.09	1.97	2.06	-0.09	-2.15
t = 10.17, WS = 0	(a)	-2.27	-2.03	-4.30	2.27	6.57
	(b)	-1.92	-1.40	-3.32	1.92	5.24
	(c)	-0.25	1.62	1.37	0.25	-1.12
t = 15.00, WS = 0	(a)	-3.65	-3.51	-7.16	3.65	10.81
	(b)	-3.28	-2.82	-6.10	3.28	9.38
	(c)	-1.61	0.14	-1.47	1.61	3.08

contd...

TABLE 19. (Contd.)

1		2	3	4	5	6
t =25.67	(a)	-6.61	-6.74	-13.35	6.61	19.96
	(b)	-6.26	-6.10	-12.36	6.26	15.26
WS = 0	(c)	-4.59	-3.08	- 7.67	4.59	18.62
t = 0	(a)	0.57	1.03	1.60	-0.06	-1.66
	(b)	0.92	1.66	2.58	-0.41	-2.99
WS = 0.51	(c)	2.59	4.68	7.27	-2.08	-9.37
t = 0	(a)	0.57	1.03	1.60	0.52	-1.08
	(b)	0.92	1.66	2.58	0.17	-2.41
WS = 1.09	(c)	2.59	4.68	7.27	-1.50	-8.77
t = 0	(a)	0.57	1.03	1.60	1.43	-0.17
	(b)	0.92	1.66	2.58	1.08	-1.50
WS = 2.00	(c)	2.59	4.68	7.27	-0.59	-7.86

Note: * Exports are considered here instead of production.

TABLE 20. (Contd.)

1		2	3	4	5	6
t = 18.35	(a)	-12.67	-2.72	-15.39	12.67	28.06
WS = 0	(b)	-11.02	2.07	- 8.95	11.02	19.97
	(c)	- 7.86	11.40	3.54	7.86	4.32
t = 0	(a)	0.19	0.58	0.77	0.32	-0.45
WS = 0.51	(b)	1.82	5.37	7.19	-1.31	-8.50
	(c)	4.98	14.70	19.68	-4.47	-24.15
t = 0	(a)	0.19	0.58	0.77	0.90	0.13
WS = 1.09	(b)	1.82	5.37	7.19	-0.73	-7.92
	(c)	4.98	14.70	19.68	-3.89	-23.57
t = 0	(a)	0.19	0.58	0.77	1.81	1.04
WS = 2.00	(b)	1.82	5.37	7.19	0.18	-7.01
	(c)	4.98	14.70	19.68	-2.98	-22.66

TABLE 21. EFFECT OF POLICY VARIABLES ON SUPPLY OF WAGONS FOR CEMENT MOVEMENTS

The estimated equations are:

(1) $L = (\text{constant})\ P^{0.45}\ t^{-0.35}\ Q^{0.49}\ C^{0.19}$

(2) $S = (\text{constant})\ t^{-0.27}\ Q^{1.38}\ L^{-0.48}$

Percentage changes in Q considered are :

(a) 4.16 , (b) 5.76 , (c) 17.00

dPV		dL	dS	dRW	dSW	dNES
1		2	3	4	5	6
t = 0	(a)	2.03	4.77	6.80	-2.03	-8.83
WS = 0	(b)	2.82	6.59	9.41	-2.82	-12.23
	(c)	8.33	19.47	27.80	-8.33	-36.13
t = 1.68	(a)	1.45	4.60	6.05	-1.45	-7.50
WS = 0	(b)	2.24	6.42	8.66	-2.24	-10.90
	(c)	7.75	19.30	27.05	-7.75	-34.80
t = 10.08	(a)	-1.49	3.75	2.26	1.49	-0.77
WS = 0	(b)	-0.70	5.55	4.85	0.70	-4.15
	(c)	4.79	18.43	23.22	-4.79	-28.01

contd...

TABLE 21. (Contd.)

1		2	3	4	5	6
t =15.93	(a)	-3.54	3.13	-0.41	3.54	3.95
WS = 0	(b)	-2.75	4.96	2.21	2.75	0.54
	(c)	2.76	17.84	20.60	-2.76	-23.36
t = 0	(a)	2.03	4.77	6.80	-1.52	-8.32
WS = 0.51	(b)	2.82	6.59	9.41	-2.31	-11.72
	(c)	8.33	19.47	27.80	-7.82	-35.62
t = 0	(a)	2.03	4.77	6.80	-0.94	-7.74
WS = 1.09	(b)	2.82	6.59	9.41	-1.73	-11.14
	(c)	8.33	19.47	27.80	-7.24	-35.04
t = 0	(a)	2.03	4.77	6.80	-0.03	-6.83
WS = 2.00	(b)	2.82	6.59	9.41	-0.82	-10.23
	(c)	8.33	19.47	27.80	-6.33	-34.13
t = 1.68	(a)	1.45	4.60	6.05	-0.96	-7.01
WS = 0.51	(b)	2.24	6.42	8.66	-1.73	-10.39
	(c)	7.75	19.30	27.05	-7.24	-34.29
t = 1.68	(a)	1.45	4.60	6.05	-0.46	-6.51
WS = 1.09	(b)	2.24	6.42	8.66	-1.15	-9.81
	(c)	7.75	19.30	27.05	-6.66	-33.71

contd....

TABLE 21. (Contd.)

1		2	3	4	5	6
t = 1.68	(a)	1.45	4.60	6.05	0.55	-5.50
WS = 2.00	(b)	2.24	6.42	8.66	-0.24	-8.90
	(c)	7.75	19.30	27.05	-5.75	-32.80
t =10.08	(a)	-1.49	3.75	2.26	2.00	-0.26
WS = 0.51	(b)	-0.70	5.55	4.85	1.21	-3.65
	(c)	4.79	18.43	23.22	-4.28	-27.50
t =10.08	(a)	-1.49	3.75	2.26	2.58	0.32
WS = 1.09	(b)	-0.70	5.55	4.85	1.79	-3.06
	(c)	4.79	18.43	23.22	-3.70	-26.92
t =10.08	(a)	-1.49	3.75	2.26	3.49	1.23
WS = 2.00	(b)	-0.70	5.55	4.85	2.70	-2.15
	(c)	4.79	18.43	23.22	-2.79	-26.01
t =15.93	(a)	-3.54	3.13	-0.41	4.05	4.46
WS = 0.51	(b)	-2.75	4.96	2.21	3.26	1.05
	(c)	2.76	17.84	20.60	-2.25	-22.85
t =15.93	(a)	-3.54	3.13	-0.41	4.63	5.04
WS = 1.09	(b)	-2.75	4.96	2.21	3.84	1.53
	(c)	2.76	17.84	20.60	-1.67	-22.27

contd....

TABLE 21. (Contd.)

1		2	3	4	5	6
t =15.93 MS = 2.00	(a)	-3.54	3.13	-0.41	5.54	5.95
	(b)	-2.75	4.96	2.21	4.75	2.54
	(c)	2.76	17.84	20.60	-0.76	-21.36

TABLE 22. EFFECT OF POLICY VARIABLES ON SUPPLY OF WAGONS FOR FOODGRAINS MOVEMENTS

The estimated equations are:

(1) $L = (\text{constant})\ P^{0.29}\ t^{-0.29}\ IMP^{-0.04}\ DC^{-0.02}$

(2) $S = (\text{constant})\ Q^{0.17}\ IMP^{-0.02}\ DC^{0.19}$

Percentage changes in Q considered are:

(a) 2.32 , (b) 7.87 , (c) 21.24

dPV		dL	dS	dRW	dSW	dNES
1		2	3	4	5	6
t = 0	(a)	0.00	0.39	0.39	0.00	-0.39
WS = 0	(b)	0.00	1.33	1.33	0.00	-1.33
	(c)	0.00	3.61	3.61	0.00	-3.61
t = 2.70	(a)	-0.78	0.39	-0.39	0.78	1.17
WS = 0	(b)	-0.78	1.33	0.55	0.78	0.23
	(c)	-0.78	3.61	2.83	0.78	-2.05
t = 9.87	(a)	-2.86	0.39	-2.47	2.86	5.33
WS = 0	(b)	-2.86	1.33	-1.53	2.86	4.39
	(c)	-2.86	3.61	0.75	2.86	2.11

contd...

TABLE 22. (Contd.)

1		2	3	4	5	6
t =15.00	(a)	-4.35	0.39	-3.96	4.35	8.31
WS = 0	(b)	-4.35	1.33	-3.02	4.35	7.37
	(c)	-4.35	3.61	-0.74	4.35	5.09
t =45.76	(a)	-13.27	0.39	-12.88	13.27	26.15
WS = 0	(b)	-13.27	1.33	-11.94	13.27	25.21
	(c)	-13.27	3.61	- 9.61	13.27	22.88
t = 0	(a)	0.00	0.39	0.39	0.51	0.12
WS = 0.51	(b)	0.00	1.33	1.33	0.51	-0.82
	(c)	0.00	3.61	3.61	0.51	-3.10
t = 0	(a)	0.00	0.39	0.39	1.09	0.70
WS = 1.09	(b)	0.00	1.33	1.33	1.09	-0.24
	(c)	0.00	3.61	3.61	1.09	-2.52
t = 0	(a)	0.00	0.39	0.39	2.00	1.61
WS = 2.00	(b)	0.00	1.33	1.33	2.00	0.67
	(c)	0.00	3.61	3.61	2.00	-1.61
t = 0	(a)	-0.08	1.19	1.11	0.08	-1.03
WS = 0	(b)	-0.08	2.13	2.05	0.08	-1.97
DC = 4.26	(c)	-0.08	4.41	4.33	0.08	-4.25

contd....

TABLE 22. (Contd.)

1		2	3	4	5	6
t = 0	(a)	-0.17	2.07	1.90	0.17	-1.73
WS = 0	(b)	-0.17	3.01	2.84	0.17	-2.57
DC = 8.87	(c)	-0.17	5.29	5.12	0.17	-4.95
t = 0	(a)	-0.36	3.90	3.54	0.36	-3.18
WS = 0	(b)	-0.36	4.84	4.48	0.36	-4.12
DC =18.48	(c)	-0.36	7.12	6.76	0.36	-6.40

TABLE 23. EFFECT OF POLICY VARIABLES ON SUPPLY OF WAGONS FOR <u>FERTILIZERS</u> MOVEMENTS

The estimated equations are :

$$(1)\ L = (\text{constant})\ P^{0.10}\ t^{-0.22}\ Q^{0.18}\ IMP^{-0.04}$$

$$(2)\ S = (\text{constant})\ P^{0.15}\ t^{-0.51}\ Q^{1.37}\ IMP^{0.55}$$

Percentage changes in Q considered are :

(a) 8.21 , (b) 16.26 , (c) 20.24

dPV		dL	dS	dRW	dSW	dNES
1		2	3	4	5	6
t = 0 WS = 0	(a)	1.47	11.24	12.71	-1.47	-14.18
	(b)	2.92	22.27	25.19	-2.92	-28.11
	(c)	3.64	27.72	31.36	-3.64	-35.00
t = 5.53 WS = 0	(a)	0.26	8.42	8.68	-0.26	-8.94
	(b)	1.71	19.45	21.16	-1.71	-22.87
	(c)	2.43	24.90	27.33	-2.43	-29.76
t =12.74 WS = 0	(a)	-1.33	4.75	3.42	1.33	-2.09
	(b)	0.12	15.78	15.90	-0.12	-16.02
	(c)	0.84	21.23	22.07	-0.84	-22.91

contd...

TABLE 23. (Contd.)

1		2	3	4	5	6
t =15.00 WS = 0	(a)	-1.83	3.59	1.76	1.83	0.07
	(b)	-0.38	14.62	14.24	0.38	-13.86
	(c)	0.34	20.07	20.41	-0.34	-20.75
t =24.48 WS = 0	(a)	-3.91	-1.24	-5.15	3.91	5.54
	(b)	-2.46	9.79	7.33	2.46	-4.87
	(c)	-1.73	15.24	13.51	1.73	-11.48
t = 0 WS = 0.51	(a)	1.47	11.24	12.71	-0.96	-13.67
	(b)	2.92	22.27	25.19	-2.41	-27.60
	(c)	3.64	27.72	31.36	-3.13	-34.49
t = 0 WS = 1.09	(a)	1.47	11.24	12.71	-0.48	-13.19
	(b)	2.92	22.27	25.19	-1.83	-27.02
	(c)	3.64	27.72	31.36	-2.55	-33.91
t = 0 WS = 2.00	(a)	1.47	11.24	12.71	0.53	-11.88
	(b)	2.92	22.27	25.19	-0.92	-26.11
	(c)	3.64	27.72	31.36	-1.64	-33.00
t = 5.53 WS = 0.51	(a)	0.26	8.42	8.68	0.25	-8.43
	(b)	1.71	19.45	21.16	-1.20	-22.36
	(c)	2.43	24.90	27.33	-1.92	-29.25

contd...

TABLE 23. (Contd.)

1		2	3	4	5	6
	(a)	0.26	8.42	8.68	0.83	-7.85
t = 5.53	(b)	1.71	19.45	21.16	-0.62	-21.78
WS = 1.09	(c)	2.43	24.90	27.33	-1.34	-28.67
	(a)	0.26	8.42	8.68	1.74	-6.94
t = 5.53	(b)	1.71	19.45	21.16	0.29	-20.87
WS = 2.00	(c)	2.43	24.90	27.33	-0.43	-27.76
	(a)	-1.33	4.75	3.42	1.84	-1.58
t =12.74	(b)	0.12	15.78	15.90	0.39	-15.51
WS = 0.51	(c)	0.84	21.23	22.07	-0.33	-22.40
	(a)	-1.33	4.75	3.42	2.42	-1.00
t =12.74	(b)	0.12	15.78	15.90	0.97	-14.93
WS = 1.09	(c)	0.84	21.23	22.07	0.25	-21.82
	(a)	-1.33	4.75	3.42	3.33	-0.09
t =12.74	(b)	0.12	15.78	15.90	1.88	-14.02
WS = 2.00	(c)	0.84	21.23	22.07	1.16	-20.91
	(a)	-1.83	3.59	1.76	2.34	0.58
t =15.00	(b)	-0.38	14.62	14.24	0.89	-13.35
WS = 0.51	(c)	0.34	20.07	20.41	0.17	-20.24

contd....

TABLE 23. (Contd.)

1		2	3	4	5	6
t =15.00	(a)	-1.83	3.59	1.76	2.92	1.16
WS = 1.09	(b)	-0.38	14.62	14.24	1.47	-12.77
	(c)	0.34	20.07	20.41	0.75	-19.66
t =15.00	(a)	-1.83	3.59	1.76	3.83	2.07
WS = 2.00	(b)	-0.38	14.62	14.24	2.38	-11.86
	(c)	0.34	20.07	20.41	1.66	-18.75
t =24.48	(a)	-3.91	-1.24	-5.15	4.42	9.57
WS = 0.51	(b)	-2.46	9.79	7.33	2.97	-4.36
	(c)	-1.73	15.24	13.51	2.24	-11.27
t =24.48	(a)	-3.91	-1.24	-5.15	5.00	10.15
WS = 1.09	(b)	-2.46	9.79	7.33	3.55	- 3.78
	(c)	-1.73	15.24	13.51	2.82	-10.69
t =24.48	(a)	-3.91	-1.24	-5.15	5.91	11.06
WS = 2.00	(b)	-2.46	9.79	7.33	4.46	- 2.87
	(c)	-1.73	15.24	13.51	3.73	- 9.78

TABLE 24. EFFECT OF POLICY VARIABLES ON SUPPLY OF WAGONS FOR MANUFACTURED ITEMS MOVEMENTS

The estimated equations are :

$$(1)\ L = (\text{constant})\ p^{0.25}\ t^{-0.11}\ Q^{0.12}$$

$$(2)\ S = (\text{constant})\ p^{-1.13}\ Q^{0.32}\ p_{P.O.L.}^{0.53}\ A^{0.91}\ MM^{2.56}$$

Percentage changes in Q considered are:

(a) 2.33 , (b) 6.39 , (c) 12.50

dPV		dL	dS	dRW	dSW	dNES
1		2	3	4	5	6
	(a)	0.27	0.74	1.01	-0.27	-1.28
t = 0	(b)	0.76	2.04	2.80	-0.76	-3.56
WS = 0	(c)	1.50	4.00	5.50	-1.50	-7.00
	(a)	0.09	0.74	0.83	-0.09	-0.92
t = 1.70	(b)	0.58	2.04	2.62	-0.58	-3.20
WS = 0	(c)	1.32	4.00	5.32	-1.32	-6.64
	(a)	-0.62	0.74	0.12	0.62	0.50
t = 8.15	(b)	-0.13	2.04	1.91	0.13	-1.78
WS = 0	(c)	0.61	4.00	4.61	-0.61	-4.61

contd....

TABLE 24. (Contd.)

1		2	3	4	5	6
t =14.41	(a)	-1.31	0.74	-0.57	1.31	1.88
Ws = 0	(b)	-0.82	2.04	1.22	0.82	-0.40
	(c)	-0.08	4.00	3.92	0.08	-3.84
t =15.00	(a)	-1.38	0.74	-0.64	1.38	2.04
Ws = 0	(b)	-0.89	2.04	1.15	0.89	-0.26
	(c)	-0.15	4.00	3.85	0.15	-3.70
t = 0	(a)	0.27	0.74	1.01	0.24	-0.77
WS = 0.51	(b)	0.76	2.04	2.80	-0.25	-3.05
	(c)	1.50	4.00	5.50	-0.99	-6.49
t = 0	(a)	0.27	0.74	1.01	0.82	-0.19
WS = 1.09	(b)	0.76	2.04	2.80	0.33	-2.47
	(c)	1.50	4.00	5.50	-0.41	-5.91
t = 0	(a)	0.27	0.74	1.01	1.73	0.72
WS = 2.00	(b)	0.76	2.04	2.80	1.24	-1.56
	(c)	1.50	4.00	5.50	0.50	-5.00
t = 1.70	(a)	0.09	0.74	0.83	0.42	-0.41
WS = 0.51	(b)	0.58	2.04	2.62	-0.07	-2.69
	(c)	1.32	4.00	5.32	-0.81	-6.13

contd...

TABLE 24. (Contd.)

1		2	3	4	5	6
t = 1.70	(a)	0.09	0.74	0.83	1.00	0.17
WS = 1.09	(b)	0.58	2.04	2.62	0.51	-2.11
	(c)	1.32	4.00	5.32	-0.23	-5.55
t = 1.70	(a)	0.09	0.74	0.83	1.91	1.08
WS = 2.00	(b)	0.58	2.04	2.62	1.42	-1.20
	(c)	1.32	4.00	5.32	0.68	-4.64
t = 8.15	(a)	-0.62	0.74	0.12	1.13	1.01
WS = 0.51	(b)	-0.13	2.04	1.91	0.64	-1.27
	(c)	0.61	4.00	4.61	-0.10	-4.71
t = 8.15	(a)	-0.62	0.74	0.12	1.71	1.59
WS = 1.09	(b)	-0.13	2.04	1.91	1.22	-0.69
	(c)	0.61	4.00	4.61	0.48	-4.13
t = 8.15	(a)	-0.62	0.74	0.12	2.62	2.50
WS = 2.00	(b)	-0.13	2.04	1.91	2.13	0.09
	(c)	0.61	4.00	4.61	1.39	-3.22
t = 14.41	(a)	-1.31	0.74	-0.57	1.82	2.39
WS = 0.51	(b)	-0.82	2.04	1.22	1.33	0.11
	(c)	0.61	4.00	3.92	0.59	-3.33

contd.....

TABLE 24. (Contd.)

1		2	3	4	5	6
t =14.41	(a)	-1.31	0.74	-0.57	2.40	2.97
WS = 1.09	(b)	-0.82	2.04	1.22	1.81	0.59
	(c)	-0.08	4.00	3.92	1.17	-2.75
t =14.41	(a)	-1.31	0.74	-0.57	3.31	3.88
WS = 2.00	(b)	-0.82	2.04	1.22	2.82	1.60
	(c)	-0.08	4.00	3.92	2.08	-1.84
t =15.00	(a)	-1.38	0.74	-0.64	1.89	2.53
WS = 0.51	(b)	-0.89	2.04	1.15	1.40	0.25
	(c)	-0.15	4.00	3.85	0.66	-3.19
t =15.00	(a)	-1.38	0.74	-0.64	2.47	3.11
WS = 1.09	(b)	-0.89	2.04	1.15	1.98	0.83
	(c)	-0.15	4.00	3.85	1.24	-2.61
t = 15.00	(a)	-1.38	0.74	-0.64	3.38	4.02
WS = 2.00	(b)	-0.89	2.04	1.15	2.89	1.74
	(c)	-0.15	4.00	3.85	2.15	-2.70

TABLE 25. EFFECT OF POLICY VARIABLES ON SUPPLY OF WAGONS FOR P.O.L. PRODUCTS MOVEMENTS*,@

The estimated equations are :

$$(1)\ L = (\text{constant})\ p^{0.30}\ t^{-0.63}\ Q^{-0.29}\ CV^{0.41} D^{0.41}$$

$$(2)\ S = (\text{constant})\ p^{0.17}\ t^{-0.06}\ Q^{0.24}\ L^{-0.09}\ CV^{0.33}$$

Percentage changes in Q considered are:

(a) 4.56 , (b) 5.10 , (c) 8.77

dPV		dL	dS	dRW	dSW	dNES
1		2	3	4	5	6
t = 0 WS = 0	(a)	0.00	1.09	1.09	0.00	-1.09
	(b)	0.00	1.22	1.22	0.00	-1.22
	(c)	0.00	2.10	2.10	0.00	-2.10
t = 1.00 WS = 0	(a)	-0.63	1.08	0.45	0.63	0.18
	(b)	-0.63	1.21	0.58	0.63	0.05
	(c)	-0.63	2.09	1.46	0.63	-0.83
t = 7.66 WS = 0	(a)	-4.82	1.07	-3.75	4.82	8.57
	(b)	-4.82	1.20	-3.62	4.82	8.44
	(c)	-4.82	2.08	-2.74	4.82	7.56

contd....

TABLE 25. (Contd.)

1		2	3	4	5	6
t =15.00 WS = 0	(a)	-9.45	1.04	-8.41	9.45	17.86
	(b)	-9.45	1.17	-8.28	9.45	17.73
	(c)	-9.45	2.05	-7.40	9.45	16.85
t =16.40 WS = 0	(a)	-10.33	1.03	-9.30	10.33	19.63
	(b)	-10.33	1.16	-9.17	10.33	19.50
	(c)	-10.33	2.04	-8.29	10.33	18.62
t = 0 WS = 0.51	(a)	0.00	1.09	1.09	0.51	-0.58
	(b)	0.00	1.22	1.22	0.51	-0.71
	(c)	0.00	2.10	2.10	0.51	-1.59
t = 0 WS = 1.09	(a)	0.00	1.09	1.09	1.09	0.00
	(b)	0.00	1.22	1.22	1.09	-0.13
	(c)	0.00	2.10	2.10	1.09	-1.01
t = 0 WS = 2.00	(a)	0.00	1.09	1.09	2.00	0.91
	(b)	0.00	1.22	1.22	2.00	0.78
	(c)	0.00	2.10	2.10	2.00	-0.10
t = 0 WS = 0 D = 0.05	(a)	-0.02	1.09	1.07	0.02	-1.05
	(b)	-0.02	1.22	1.20	0.02	-1.18
	(c)	-0.02	2.10	2.08	0.02	-2.06

contd....

TABLE 25. (Contd.)

1		2	3	4	5	6
t = 0 WS = 0 D = 0.31	(a)	-0.12	1.10	0.98	0.12	-0.86
	(b)	-0.12	1.23	1.11	0.12	-0.96
	(c)	-0.12	2.11	1.99	0.12	-1.87
t = 0 WS = 0 D = 2.91	(a)	-1.19	1.19	0.00	1.19	1.19
	(b)	-1.19	1.32	0.13	1.19	1.06
	(c)	-1.19	2.20	1.01	1.19	0.18

Note: * We are considering changes in Q in the S equation only.

@ Since D is an index of concentration we take the negative of the percentage changes in D to reflect dispersal.

TABLE 26. EFFECT OF POLICY VARIABLES ON SUPPLY OF WAGONS FOR AGGREGATE MOVEMENTS

The estimated equations are :

$$(1)\ L = (\text{constant})\ P^{0.17}\ t^{-0.04}\ Q^{0.10}$$

$$(2)\ S = (\text{constant})\ Q^{0.88}\ L^{-0.64}$$

Percentage changes in Q considered are:

(a) 2.36 , (b) 4.23 , (c) 12.77

dPV		dL	dS	dRW	dSW	dNES
1		2	3	4	5	6
t = 0	(a)	0.23	1.93	2.16	-0.23	-2.39
WS = 0	(b)	0.42	3.47	3.89	-0.42	-4.31
	(c)	1.27	10.42	11.69	-1.27	-12.96
t = 2.51	(a)	0.13	1.99	2.12	-0.13	-2.25
WS = 0	(b)	0.32	3.52	3.84	-0.32	-4.16
	(c)	1.17	10.49	11.66	-1.17	-12.83
t = 9.91	(a)	-0.16	2.17	2.01	0.16	-1.85
WS = 0	(b)	0.03	3.71	3.74	-0.03	-3.77
	(c)	0.88	10.67	11.55	-0.88	-12.43

contd....

TABLE 26. (Contd.)

1		2	3	4	5	6
t =13.40 WS = 0	(a)	-0.30	2.26	1.96	0.30	-1.66
	(b)	-0.11	3.79	3.68	0.11	-3.57
	(c)	0.74	10.76	11.50	-0.74	-12.24
t =15.00 WS = 0	(a)	-0.37	2.30	1.93	0.37	-1.55
	(b)	-0.18	3.83	3.65	0.18	-3.47
	(c)	0.67	10.81	11.48	-0.67	-12.15
t = 0 WS = 0.51	(a)	0.23	1.93	2.16	0.28	-1.88
	(b)	0.42	3.47	3.89	0.09	-3.80
	(c)	1.27	10.42	11.69	-0.76	-12.45
t = 0 WS = 1.09	(a)	0.23	1.93	2.16	0.86	-1.30
	(b)	0.42	3.47	3.89	0.67	-3.22
	(c)	1.27	10.42	11.69	-0.18	-11.87
t = 0 WS = 2.00	(a)	0.23	1.93	2.16	1.77	-0.39
	(b)	0.42	3.47	3.89	1.58	-2.31
	(c)	1.27	10.42	11.69	0.73	-10.96
t = 2.51 WS = 0.51	(a)	0.13	1.99	2.12	0.38	-1.74
	(b)	0.32	3.52	3.84	0.19	-3.65
	(c)	1.17	10.49	11.66	-0.66	-12.32

contd....

TABLE 26. (Contd.)

1		2	3	4	5	6
t = 2.51	(a)	0.13	1.99	2.12	0.96	-1.16
WS = 1.09	(b)	0.32	3.52	3.84	0.77	-3.07
	(c)	1.17	10.49	11.66	-0.08	-11.74
t = 2.51	(a)	0.13	1.99	2.12	1.87	-0.25
WS = 2.00	(b)	0.32	3.52	3.84	1.68	-2.16
	(c)	1.17	10.49	11.66	0.83	-10.83
t = 9.91	(a)	-0.16	2.17	2.01	0.66	-1.55
WS = 0.51	(b)	0.03	3.71	3.74	0.48	-3.26
	(c)	0.88	10.67	11.55	-0.37	-11.92
t = 9.91	(a)	-0.16	2.17	2.01	1.25	-0.76
WS = 1.09	(b)	0.03	3.71	3.74	1.06	-2.68
	(c)	0.88	10.67	11.55	0.21	-11.34
t = 9.91	(a)	-0.16	2.17	2.01	2.16	0.15
WS = 2.00	(b)	0.03	3.71	3.74	1.97	-1.77
	(c)	0.88	10.67	11.55	1.12	-10.43
t = 13.40	(a)	-0.30	2.26	1.96	0.81	-1.15
WS = 0.51	(b)	-0.11	3.79	3.68	0.62	-3.06
	(c)	0.74	10.76	11.50	-0.23	-11.73

contd.....

TABLE 26. (Contd.)

1		2	3	4	5	6
t =13.40 WS = 1.09	(a)	-0.30	2.26	1.96	1.39	-0.57
	(b)	-0.11	3.79	3.68	1.20	-2.48
	(c)	0.74	10.76	11.50	0.35	-11.15
t =13.40 WS = 2.00	(a)	-0.30	2.26	1.96	2.30	0.34
	(b)	-0.11	3.79	3.68	2.11	-1.57
	(c)	0.74	10.76	11.50	1.26	-10.24
t =15.00 WS = 0.51	(a)	-0.37	2.30	1.93	0.88	-1.05
	(b)	-0.18	3.83	3.65	0.69	-2.96
	(c)	0.67	10.81	11.48	-0.16	-11.64
t =15.00 WS = 1.09	(a)	-0.37	2.30	1.93	1.46	-0.47
	(b)	-0.18	3.83	3.65	1.27	-2.38
	(c)	0.67	10.81	11.48	0.42	-11.06
t =15.00 WS = 2.00	(a)	-0.37	2.30	1.93	2.37	0.44
	(b)	-0.18	3.83	3.65	2.18	-1.47
	(c)	0.67	10.81	11.48	1.33	-10.15

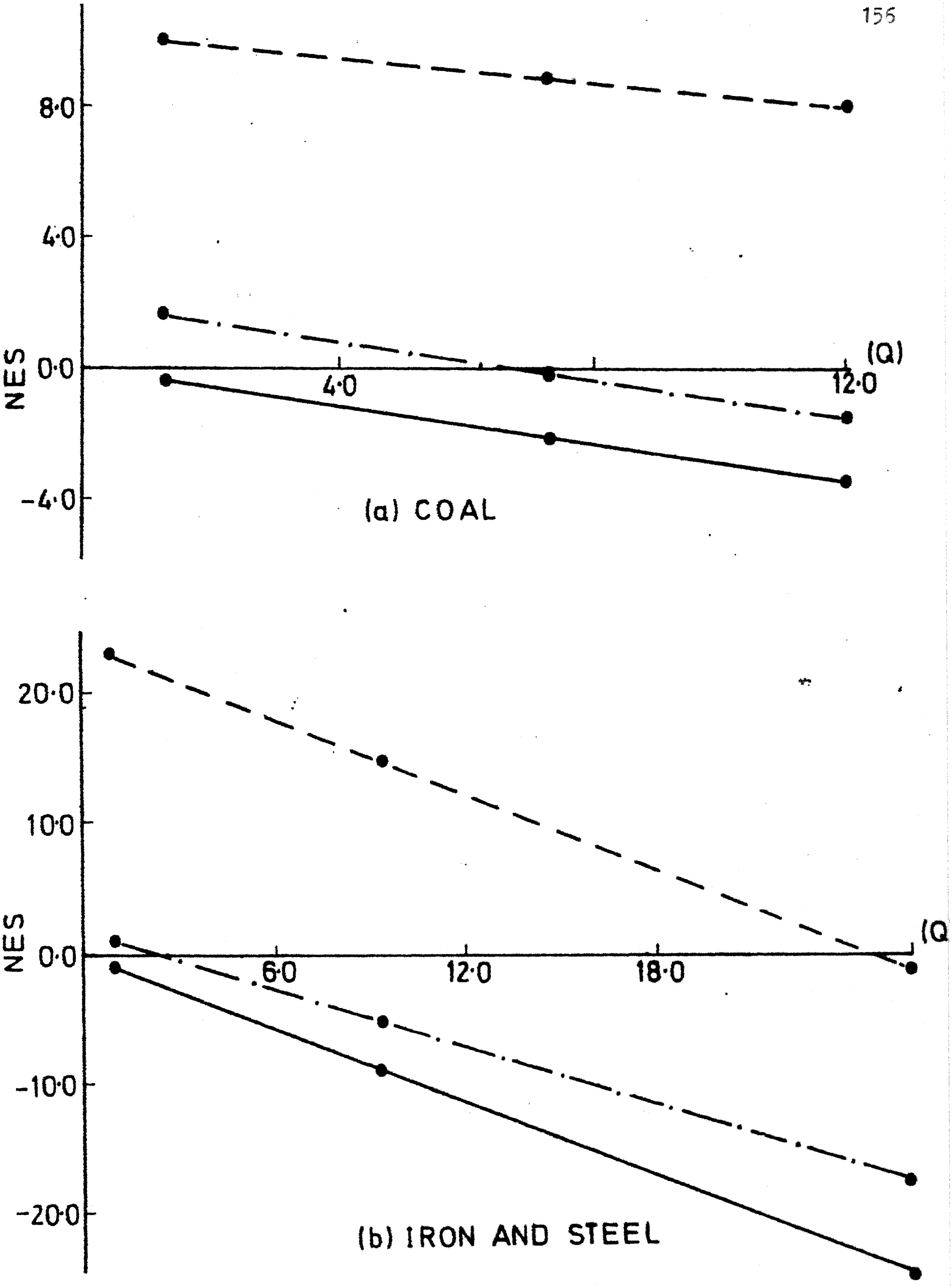

FIG.7 NET EXCESS SUPPLY OF WAGONS(i)

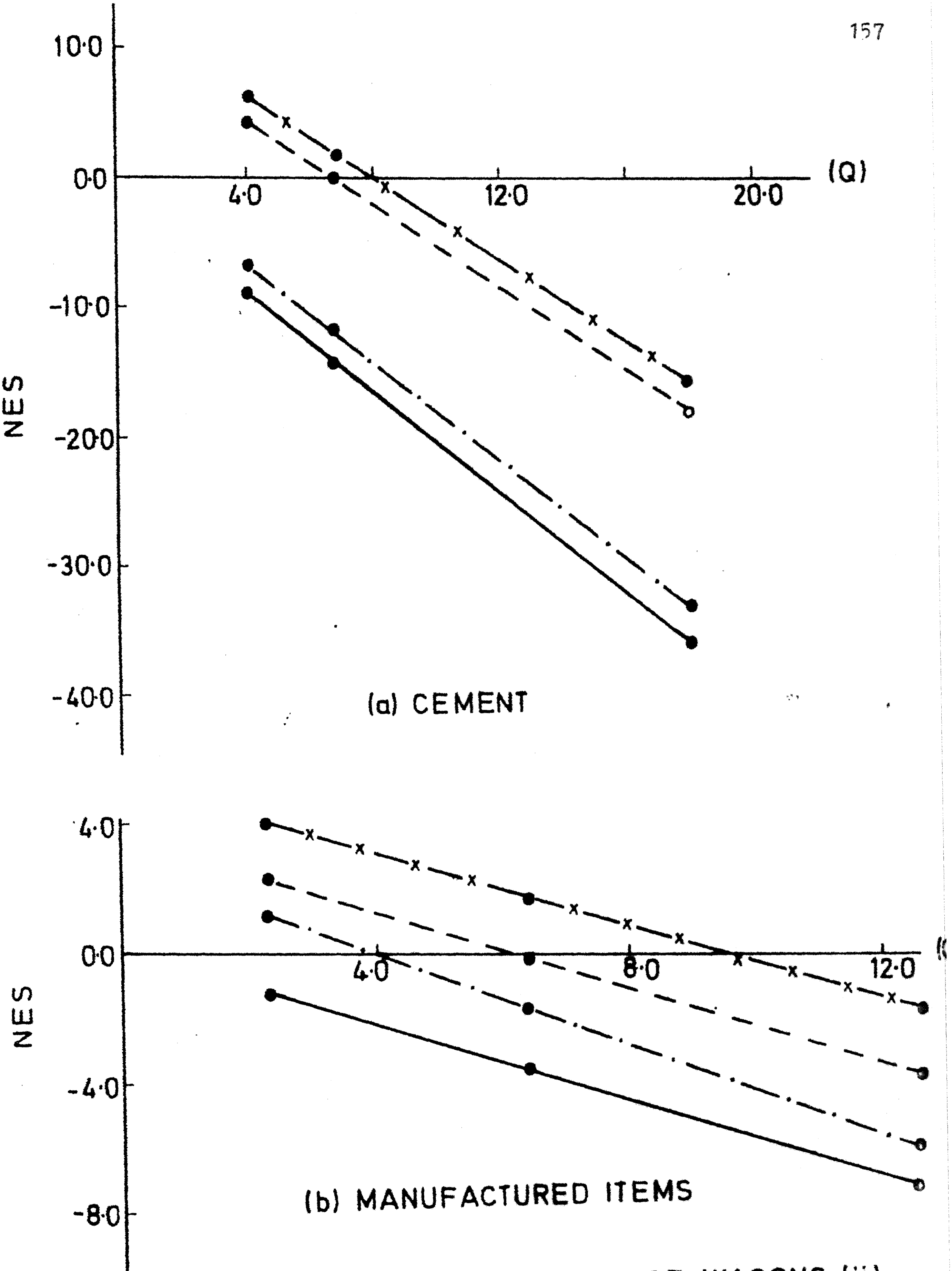

FIG.8 NET EXCESS SUPPLY OF WAGONS (ii)

Note for Figures 7 and 8:

(1) The (Q) on the horizontal axis is the rate of growth of output.

NES on the vertical axis is the rate of growth of net excess supply of wagons.

(2) ———— is the trend in NES for changes in Q only.

-------- is the trend when a rate of change of t = 15.00 is introduced.

-.-.-.- is the trend when a rate of change of WS = 2.00 is considered.

-x-x-x- is the trend when both the above changes operate simultaneously.

CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 MAJOR FINDINGS

This study was motivated by the observation that the Indian Railway System has been, for quite sometime, characterized by acute and ever increasing shortage of wagons. The disequilibrium in the system is a result, on the one hand, of the increases in the demand for freight services and shortfall in the supply, on the other.

The present study made an attempt to examine the extent to which the location of production and consumption centres, and the behavioural patterns of freight shippers with respect to the quantum shipped and length of haul had an effect on the supply of freight services.

In order to study these interrelationships we developed a behavioural model of the shipper's decisions regarding the length of haul and quantum shipped. It was then possible to develop expressions for the requirement and supply of wagons.

The analysis has been empirically validated for disaggregated commodity movements on the Indian Railways. The following results were shown to be significant: (a) the

length of haul, and not the quantum shipped, is sensitive to variations in the transport rates and output prices, (b) growth and regional patterns of availability and demand have a major role in determining both the length of haul and quantum shipped. The demand factors predominate in both the decision processes, and (c) expected speculative movements, due to increases in the length of haul, have not materialized as yet. However, the supply bottleneck dominates purely in terms of delays as a result of increases in the length of haul.

The modelling framework also enabled us to examine, on the basis of a simulation exercise, the efficacy of certain alternative policy measures in relation to their ability to alleviate dynamic disequilibrium in the wagon supply.

The major exogenous change which contributes to wagon requirements is taken to be the growth in output in the case of each commodity. Policies relating to the freight rate and wagon stock may be expected to improve wagon supply. These are, essentially, the policy options considered in the simulation.

A major finding is that changes in freight rates and wagon stock can have the effect of creating a net excess

supply of freight services for most commodities. The freight rate policy seems more efficacious of the two alternatives. However, in the case of fertilizers and cement, even a combination of the two policies appears inadequate to solve the problem. A policy of developing a regional distribution network through warehouses and better scheduling of freight services may be essential in getting a solution to the problem.

7.2 COMMENTS AND CAVEATS

Throughout the present study we maintained that the basic source of disequilibrium is the increase in the length of haul. However, while it is true that the length of haul has an important effect on the demand for wagons, it is important to realize that the supply of wagons is conditioned by other factors as well. For, suppose the average length of haul of 650 Kms is covered at a speed of 40 Kmph. Then, the average turnaround time of wagons would be only 32.5 hours. Even allowing an equal amount of time for detention time at marshalling yards the average turnaround time cannot exceed 3 days. But the observed average is 16.5 days. This indicates that the management of wagon movements is itself a major cause of the reduction in wagon supply. We could not however examine this due to limitations of a

theoretical framework as well as data sources.

If the turnaround time of wagons is as high as was noted and if demand for goods and services at certain destinations is being fulfilled it would mean that a disproportionate allotment of wagons is made on certain sections and for some commodities. This too has the effect of reducing wagon supply. It would be worthwhile to examine such micro-level details.

We also noted that the effect of increasing freight rates is to reduce the quantum shipped. From the point of view of the railway management such an effect may be welcome, at least in the short run, because of the need to relieve the pressure on the system. But this would have important effects on the economy as a whole. The partial equilibrium assessment of the policy options always has such a limitation and we did not attempt to develop any general models.

In the simulation exercise the freight rate changes were considered under the assumption that the costs of providing services remain invariant. But it is elementary to note that the changes in fuel prices have had a fundamental bearing on costs. Even from this viewpoint the model of supply of freight services remains to be strengthened.

In the context of a proposal for a regional distribution system, the policy of providing warehousing facilities needs to be studied in greater detail. For, while there may be some improvement in the wagon supply due to better scheduling of shorter haulages there are two other cost aspects. Firstly, a shorter haul increases originating tonnage the way it is accounted for in official records. Essentially, this results in an increased cost of loading and unloading. Secondly, there are additional costs, both capital and operating, of the warehousing facilities. Once again the partial equilibrium evaluation is inadequate.

There is a need to develop a more comprehensive behavioural model of the railway management in terms of its decisions regarding the acquisition of wagon stock, length of haul in freight movements, scheduling the use of existing tracks as reflected in the dispatches of wagons from a given location, detention times at marshalling yards, and empty wagon movements. All of these factors contribute to the patterns of wagon availability.

This is a far more difficult task because both the theoretical insights necessary to deal with it as well as the data base are at present not available. It is nevertheless worthwhile if the railway management wishes to develop a comprehensive plan of efficient management of freight services.

REFERENCES

1. Allen, W.B., The Demand for Freight Transportation: A Micro Approach, Transportation Research, February 1977, pp. 9-14.

2. Anderson, J.E., A Theoretical Foundation for the Gravity Equation, American Economic Review, March 1979, pp. 106-115.

3. Baumol, W.J., and H.D. Vinod, An Inventory Theoretic Model of Freight Transport Demand, Management Science, March 1970, pp. 413-421.

4. Benheddi, A., and D.E. Pitfield, Industrial Heterogeneity and Spatial Hierarchy in Multi-regional Freight-generation Models, Environment and Planning A, July 1980, pp. 787-797.

5. Black, W.R., Interregional Commodity Flows: Some Experiments with the Gravity Model, Journal of Regional Science, April 1972, pp. 107-118.

6. Boyer, K.D., Minimum Rate Regulation, Modal Split Sensitivities, and the Railroad Problem, Journal of Political Economy, June 1977, pp. 497-512.

7. Chung, C.C., and P.O. Roberts, Design of a Structure and Data Analysis Scheme for Inter-City Freight Demand Forecasting, M.I.T., C.T.S., Report No.75-15, September 1975, pp. 16-49.

8. Daughety, A.F., Inaba, F.S., and T.Zlatoper, Demand for Freight Literature Review, Northwestern University, Working Paper No.601-76-04, May 1976.

9. Daughety, A.F., and F.S. Inaba, Empirical Aspects of Service-Differentiated Transport Demand Motor Carriers Economic Regulation, Proceedings of Workshop sponsored by the National Academy of Sciences, April 1977.

10. Daughety, A.F., and F.S. Inaba, Modelling Service-Differentiated Demand by Freight Transportation Theory, Regulatory Policy Analysis, Demand Estimation, Proceedings of National Symposium on Transportation for Agricultural and Rural America, U.S.Department of Transportation, August 1977.

11. Daughety, A.F., and F.S. Inaba, Estimating Service-Differentiated Transport Demand Functions, Transportation Research Record, 668, 1978, pp. 23-30.

12. Daughety, A.F., Freight Transport Demand Revisited: A Micro Economic View of Multimodal, Multicharacteristic Uncertainity and Demand for Freight Transport, Transportation Research, December 1979, pp. 281-288.

13. Daughety, A.F., and F.S. Inaba, An Analysis of Regulatory Change in the Transportation Industry, to appear in Review of Economics and Statistics, 1981.

14. Fresko, D., Shunk, G., and F.Spielberg, Analysis of the Need for Goods Movement Forecasts, Journal of the Urban Planning and Development Division of the ASCE, March 1972, pp. 1-16.

15. Friedlaender, A.F., and I. Harrington, Intermodalism and Integrated Transport Companies in the United States and Canada, Journal of Transport Economics and Policy, September 1979, pp.247-267.

16. Hariton, G., et. al, Econometric Forecasting- Demand for Freight Transport in Canada, Canadian Transport Commission, Report No.ESAB-76-16-5, June 1976a, pp. 8-17.

17. Hariton, G., Zohar, U., Le, C.D., and R.S.H.Lee, Demand for Freight Transportation in Canada, International Journal of Transport Economics, August 1976b, pp. 49-62.

18. Hutchinson, B.G., Estimating Urban Goods Movement Demands, Transportation Research Record, 1974, pp. 1-15..

19. Johnston, J., Econometric Methods, Second Edition, (Tokyo: McGraw-Hill Kogakusha, 1972), p.377.

20. Kadekodi, G., Iron Ore Export - Its Relevance for India, Productivity, May 1979.

21. Khosal, R.K., Economics of Broad Guage Railways: Indian Experience, Indian Economic Journal, January 1971, pp. 347-370.

22. Khosla, G.S., Railway Management in India (Bombay: Thacker, 1972).

23. Lefeber, L., and M. Datta Chaudhari, Transportation Policy in India, in P.N. Rosenstein - Rodan (ed.) Pricing and Fiscal Policies (Cambridge: M.I.T. Press, 1964).

24. Levin, R.C., Allocation in Surface Freight Transportation: Does Rate Regulation Matter?, The Bell

Journal of Economics, Spring 1978, pp.18-45.

25. Loose, V.W., and L. Roueche, Impact of Congestion on Transportation Levels: Case of Ferry Transportation, Transportation Research, April 1979, pp. 79-82.

26. Maejima, T., An Application of Continuous Spatial Models to Freight Movements in Greater London, Transportation, 1979, pp. 51-63.

27. Miller, S.M., and O.W. Jensen, Location and the Theory of Production, Regional Science and Urban Economics, May 1978, pp. 117-128.

28. Morlok, E.K., Short Run Supply Functions with Decreasing User Costs, Transportation Research, September 1979, pp. 183-187.

29. Nazem, S.M., Entropy of Freight Transportation and Price Variation, European Journal of Operations Research, September 1979, pp. 413-416.

30. Niedercorn, J.H., and B.V. Bechdolt, Jr., An Economic Derivation of the "Gravity Law" of Spatial Interaction, Journal of Regional Science, August 1969, pp.273-282.

31. Ogden, K.W., An Analysis of Urban Commodity Flow, Transportation Planning and Technology, 1977, pp. 1-9.

32. Ogden, K.W., The Distribution of Truck Trips and Commodity Flow in Urban Areas: A Gravity Model Analysis, Transportation Research, April 1978, pp. 131-137.

33. Oum, T.H., Derived Demand for Freight Transport and Inter-Modal Competition in Canada, Journal of Transport Economics and Policy, May 1979, pp. 148-168.

34. Palaniswamy, S.P., and S. Gangopadhyay, Technological Forecasting in Transportation (A Delphi Study), NCST Panel on Futurology, Mimeographed, May 1979.

35. Parikh, J.K., Modelling Approach to Long-Term Energy Demand and Energy Policy Implications (New Delhi: Government of India, Planning Commission, June 1980).

36. Parikh, K.S., and T.N. Srinivasan, Food and Energy Choices for India (Laxenburg: IIASA, 1977), p.8.

45. Rao, P.S., and G.R.Sparks, Econometric Forecasting of Railway Freight Demand, Canadian Institute of Guided Ground Transport, Report No.78-4, December 1978.

46. Rao, T.V.S.R., Sriraman, S., and S.P.Palaniswamy, Length of Haul in Freight Movements, International Journal of Transport Economics, to appear in 1981.

47. Shah, C.H., Narayanamurthy, S.G., Gopalakrishnan, T.R., and B. Bhaskara Rao, India in Perspective, Vol. 3 (New Delhi: Arnold Heinemann 1978).

48. Sloss, J., The Demand for Inter-City Motor Freight Transport- A Macro Economic Analysis, Journal of Business, January 1971, pp.62-68.

49. Smith, P.L., Forecasting Freight Transport Demand - The State of the Art, The Logistics and Transportation Review, 1974, pp. 311-326.

50. Srichand, S., Deceleration in Wagon Loadings, The Economic Times, April 27, 1980.

51. Taborga, P.N., The Economic Role of Railways - Determinants of Railway Traffic: Phase I Final Report, World Bank Mimeograph, 1979.

52. The Economic Times, Railway Deficit Trimmed, The Economic Times, March 7, 1980.

53. The Economic Times, Coal Dumps for 6 States, The Economic Times, September 11, 1980.

54. The Hindu , Can the Railways Face the Challenge?, The Hindu, August 11, 1980.

55. Wilson, A.G., Entropy in Urban and Regional Modelling (London : Pion, 1970).

56. Wilson, L.B., and N.K. Taneja, Disaggregated Mode- Share Models for Air Freight Policy Analysis, Transportation Research, April 1979, pp. 115-123.